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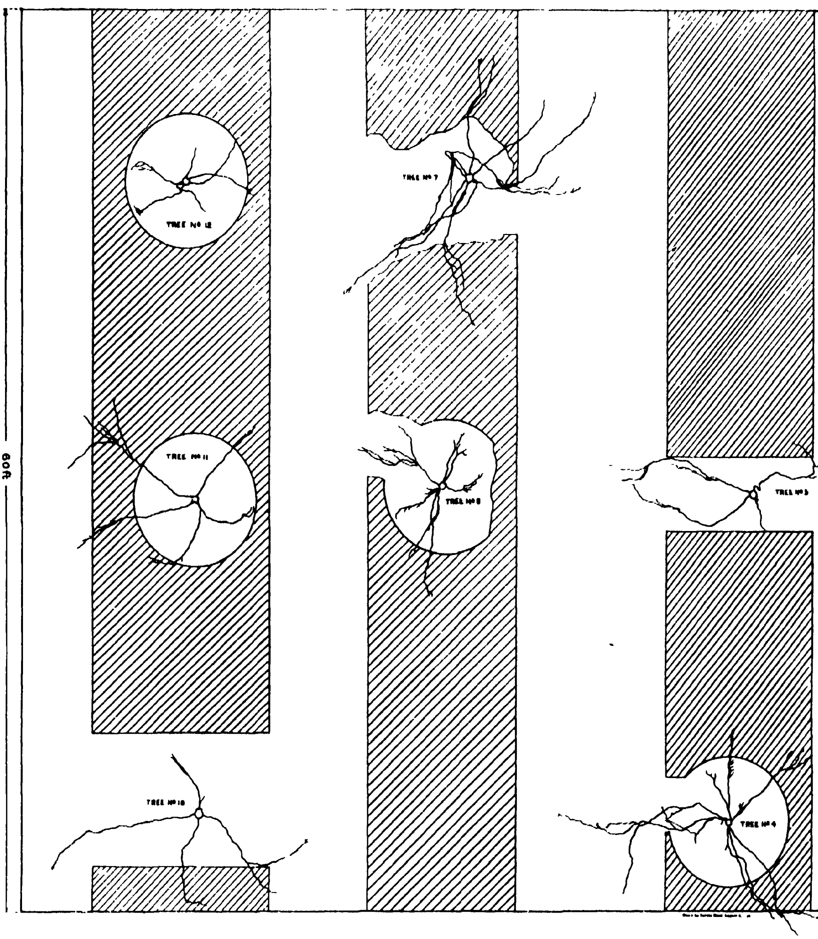

PLATE I.—ROOT DEVELOPMENT OF GRAPEFRUIT, *Citrus paradisi* VAR. *Walters* ON ROUGH LEMON (CROSS-HATCHED AREA WITH THICK COVER OF *Calopogonium mucunoides*).

Lateral roots of seven grapefruit trees (*Citrus paradisi*), originally imported from Florida (root stock—Rough lemon) and partly or fully surrounded by a perennial cover of *Calopogonium mucunoides*, were exposed for study by the writer in January, 1938. The data gathered during this study are presented in Table I. and in the accompanying diagrams in Plate I.

The following inferences can be drawn from these observations :—

(1) The lateral roots remain within 3 to 6 inches of the soil surface up to the periphery of the crown, but as soon as the roots come in contact with the cover they either turn back into the open space underneath the crown or penetrate into deeper layers and only in a very few cases do they extend into the space occupied by the cover.

(2) Where the roots of citrus trees extend into the cover they generally penetrate underneath the main nodular root zone of the cover crop and not through it.

(3) The main nodular root zone of the cover occupies the superficial layer of the soil up to a depth of three inches, but occasionally a deep stout sucker root penetrates to a depth of about one foot from the surface and is found in the citrus root zone below. It is roots of this type which keep the cover green when the water supply near its surface roots is exhausted in the dry weather and which incidentally compete with the roots of the fruit tree.

(4) Young grapefruit trees, four years old, which had open spaces on two sides, extended their lateral roots on these sides far beyond the limit of the tree crown, up to 2 to 3 times the spread of branches ; while the roots on the sides under the cover crop remained more or less restricted to the uncovered space underneath the tree crown.

Full exposure of all the lateral roots of a nine year old grapefruit tree, permanently surrounded by a cover of *Indigofera endecaphylla*, showed that the lateral root growth extended only a little beyond the periphery of the crown and did not appreciably mingle with the roots of the adjoining trees situated fourteen feet away on either side.

The above observations clearly indicate that citrus roots are not able to maintain the same growth ratio in association with a permanent cover as without it and that for the free development of their roots they require the soil beyond the drip of the tree crown to be free from competition for water by other roots.

The writer's observations on the development of citrus trees in cultivated soil unassociated with a permanent cover under dry

weather conditions prevailing in Western India (Poona) are interesting in connection with the present study of tree root behaviour. These observations were made at the Ganeshkhind Fruit Experiment Station, Kirkee, near Poona. This part of Western India is subject to the south-west monsoon which commences in June and ends in September. The total annual rainfall amounts to about 25 inches. The soil is a shallow medium black loam, about 3 feet deep, overlying a disintegrating trap rock. During the rains, temporary cover crops of *Phaseolus* and *Crotolaria* spp. are grown in the open space left between the young trees. These cover crops are ploughed in as green manure at the end of the rains by means of a light iron plough drawn by a single pair of bullocks. At the commencement of the dry weather in October or November, the orchard land is harrowed and prepared for irrigation. Square basins about 6 to 8 inches deep and as wide as the spread of branches are prepared round each tree and irrigation given at short or long intervals according to weather conditions. The ground in the basin is hand cultivated at intervals to remove weeds and to incorporate manures. Ploughings, harrowings and subsequent hand cultivation help to maintain a perpetual mulch of loose earth to a depth of 6 inches above the superficial roots of the tree. The following observations were made by the writer while on the staff of the Department of Agriculture, Bombay, in the years 1935–1937 :—

(1) In a young four-year old Mosambi orange (*Citrus sinensis*) orchard spaced 18 feet by 18 feet, the spread of the crown of the tree was 12 feet leaving 6 feet space between two adjoining trees. The roots had spread uniformly all round within a radius of 9 to 16 feet from the trunk as against the crown spread which ranged within a radius of 5½ feet to 6½ feet from the trunk.

Thus at the very young age of four years the roots of each tree had penetrated to a considerable distance beyond the spread of its branches and had intermingled with the roots of neighbouring trees.

(2) Grapefruit trees *Citrus paradisi* (variety Marsh's Seedless on Rough lemon root stock) spaced 25 feet, showed that five year old trees developed a crown with a spread of 12 to 14 feet and that the roots penetrated to a distance of 12 to 16 feet round the trunk as against the radial spread of 6 to 7 feet of the crown. Plate II. illustrates the root development of these trees.

Observations on 15-year old Santara (mandarine) orange 15 feet apart indicated that the branches of adjoining trees had so intermingled that there was inadequate sunshine in the orchard

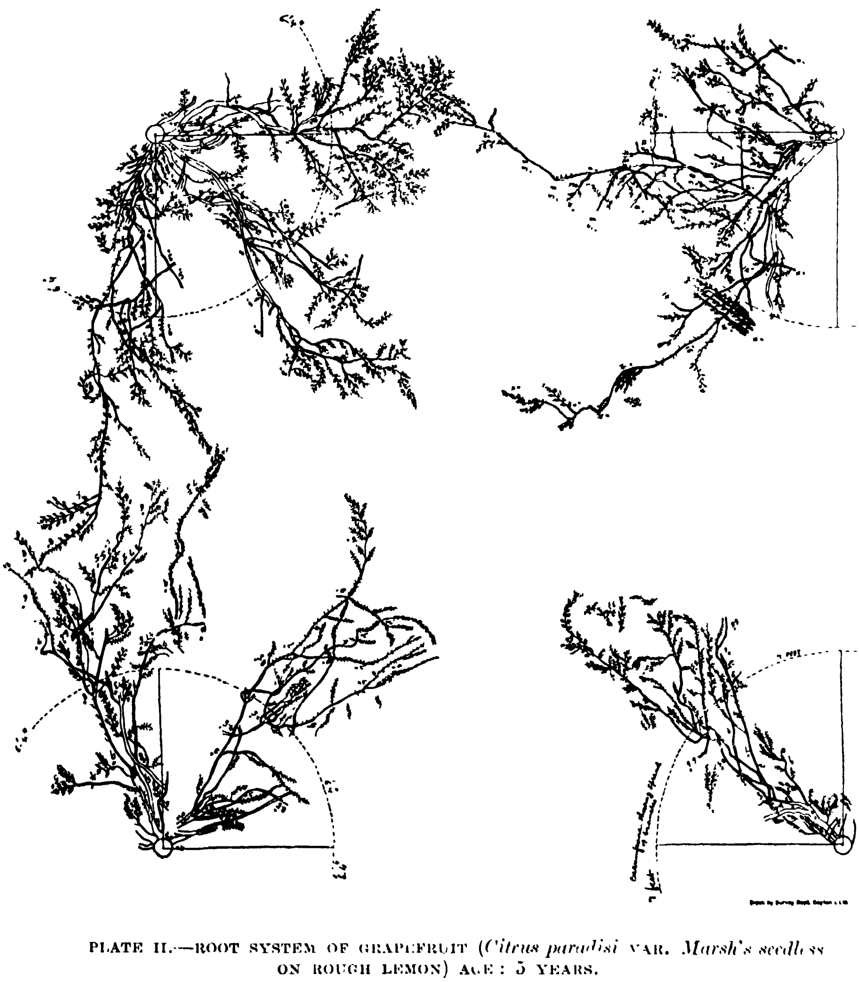

PLATE II.—ROOT SYSTEM OF GRAPEFRUIT (*Citrus paradisi* VAR. *Marsh's seedless* ON ROUGH LEMON) AGE : 5 YEARS.

and the roots of one tree had actually penetrated up to the trunk of its neighbour. These observations were made by the writer in the year 1930, on a plantation in Sind where the soil was a deep alluvium and was clean cultivated but not green manured. The annual rainfall was a little less than seven inches and the climatic conditions were extremely hot and dry. Under the circumstances the trees had to be irrigated throughout the year.

It is a very general and common experience in India that closely spaced citrus orchards continue to bear as long as there is ample sunshine in the orchard and there is an open space of four to eight feet round the trees ; but as soon as the space between the trees is covered by the spreading branches the decline of the trees sets in and, in a few years, the yield and quality of fruit deteriorate to such an extent that it is not worth while to maintain the orchard.

Burns and Kulkarni (1), while studying certain fruit trees attacked by die-back in the year 1920, recorded the following observations on the rooting habit of the Santara orange, budded on Jamburi (Rough lemon) root stock, 14 years old, and growing in deep medium black soil at Kirkee, near Poona :—

"There are well developed lateral roots growing in all directions to an average radius of 10 feet, several roots being as far as 16 feet, the mean point of origin of these laterals being about 9 inches below the soil surface."

Similar observations on Mosambi orange trees have been recorded by the same authors.

DISCUSSION

In view of the foregoing observations it is clear that the lateral roots of citrus trees in wet, as well as dry, countries are capable of extending to a distance of 2 to 3 times the spread of the branches provided there is no other perennial vegetation growing in the soil which may be occupied by the tree roots. The value of a perennial cover in preventing erosion and adding humus to soils in the wet tropical regions is unquestionable ; but the present observations clearly emphasize the desirability of a modification in the system of cover cropping so as to afford a chance for the full natural development of lateral roots and at the same time to keep the unoccupied soil protected from erosion by torrential rains. The present observations pointedly raise the question of competition for water between roots of fruit trees and cover crops.

The quick-growing roots of cover crops entirely monopolize the water content in the first three inches of the surface soil and thus effectively prevent the advance of the slow growing lateral roots of the newly planted young trees into the covered space beyond the drip of the crowns. Under the circumstances, the

lateral tree roots which are by nature surface feeding in habit have either to tap the deeper layers beneath the root zone of the cover or turn back into the open space underneath the crown in search of moisture. A few roots do extend beneath the cover. This occurs whenever there is an opportunity of finding sufficient moisture in the soil below the nodular roots of the cover. It must be realized that the tree roots that extend beneath the cover have the distinct disadvantage of suffering from lack of moisture, especially in a period of drought. When falls of rain are slight (below ·75 inches) and occur at long intervals, all the rain water is likely to be utilized by the cover, and is not able to penetrate deeper to reach the tree roots beneath. The wilted condition of the citrus trees when the above observations were made during the serious drought that prevailed in January, 1938, was an indication of the adverse effect of a permanent cover growing above the roots of citrus trees. Citrus trees which are usually in fruit almost throughout the year at Peradeniya often get a very serious set-back due to the absence of sufficient moisture near their roots during such droughts. Very similar observations on effects of cover crops on citrus trees in Australia have been recorded by West and Howard (10) in a recent publication. They say " The summer-growing leguminous green manure crop (cow pea) caused a decrease in growth and yield of the trees owing to the competition of the cow peas for soil moisture while the winter-grown leguminous green manure crop (tick beans) has increased the growth and yield of trees as compared with clean cultivation. The perennial crop (lucerne) has greatly decreased the growth and yield of the trees owing to the very severe competition of this plant for soil moisture".

To avoid, therefore, the arresting influence of the cover it is suggested by the writer that from the time the young tree is planted, the cover should be continually kept a little away from the advancing lateral roots. This should be done up to twice the spread of branches (the usual length to which the citrus roots extend under favourable conditions), and the uncovered space around the tree should be kept deeply forked to keep off weeds and to absorb all the rain water that falls within that area. The cover should be clipped several times during the year and the prunings spread over the root area underneath the tree and also beyond the drip as a mulch. These prunings would rot under the influence of occasional showers and add humus to the soil. If the land is fairly level and well terraced the danger of soil erosion is reduced to a minimum by adopting the above method of soil management; however, if the land is hilly or undulating and the soil shallow, erosion of the loose soil round the young tree is bound to occur during periods of torrential rains. Under the circumstances it would be well to grow

temporary cover crops close to the tree trunk during the heavy rains, and to uproot and leave them on the ground surface to rot as green manure a little before the close of the rainy period. In the dry zones of Ceylon subject to one monsoon it would certainly be advantageous to adopt the Indian system of growing temporary cover crops in the open space between trees during the rains only and to bury them as green manure towards the close of the monsoon.

SPACING OF FRUIT TREES

From the observations noted above it is evident that the growth ratio between root and shoot of young citrus trees, as contrasted with those more or less equally spaced but of advanced age, emphasizes the necessity of wider spacing of trees in the orchard. The actual spacing to be given to a variety of fruit tree in an orchard will depend upon the maximum spread attained by lateral roots and branches of that variety under a particular set of soil and climatic conditions. While determining the spacing, due regard should also be given to factors such as the type of cultivation, methods of irrigation, spraying, and handling of fruits.

MANURING AND IRRIGATION

The present study has shown that a considerable portion of the root system of citrus trees lies far beyond the drip of the tree crown. It follows that irrigation and manure should be given on a much wider area than that covered by spread of the branches, which is the usual practice in Ceylon and India. It is well known that the actual feeding organs of the root which take up nourishment from the soil are the fine fibre-like organs, and the naked, cord like, thick roots are mere carriers of supply drawn by the feeders.

Hatton and Rogers (4), commenting upon the question of manuring apple trees at East Malling in England, say that the fibrous roots, which carry the actual feeding organs of the root, are fairy evenly distributed over the whole root area and therefore that " for efficient feeding, manure should be spread over an area even wider than that covered by the branches, and not, as is often the case, in a little ring just round the trunk". In order to ascertain the distribution of the fibrous roots Rogers and Vyvyan (7) of East Malling employed the method of removing the soil of the whole root area in definite blocks and determined the amount of the fibre in each block.

So far as the object of the present study is concerned it has not been considered necessary to adopt the expensive and very laborious method employed at East Malling. Mere top exposure of laterals which lie within the first 4 to 8 inches of the ground surface is enough to give a general idea as to the nature

of these fibrous roots and their position in the root system. In almost all cases examined by the writer at Peradeniya, the massive parts of the root system close to the trunk had the least "fibre" while the rest of the root system showed varied behaviour. In some trees the fibre was more concentrated midway between the drip and the trunk while in others it was found at about the point of drip or much further away on the extreme parts of the root system. These fibrous feeding roots in the case of fully grown trees form a solid mass and extend very close to the soil surface. These surface fibres get torn and destroyed in cultivation without apparent injury to the trees and new ones arise annually after the cultivation ceases and water is given in a systematic way. The regeneration of a seasonal crop of fibres either on the main roots or their multiple branches seems to depend largely upon the stimulus received from the manurial and cultural treatment given to the tree during the growing season. The general tendency of the fibre is to concentrate nearer the ground surface where warmth, air, moisture and fertilizers are easily accessible. In fact, the life of the fibres is transitory. Under the favourable conditions mentioned above they regenerate and multiply. In the absence of these conditions they perish.

The depth of rooting, lateral spread of main and subsidiary roots and their branching and the quantity of fibre are specific characters. These specific characters may vary with different species, but the location of fibre on the root system does not seem to be a specific character. It appears to be more a result of environment and cultural treatment. In fact, there is no natural pattern of fibres located on a particular part of the root system of a species which might serve as a guide for the application of manures. Every bit of the root system, whether a thick cord-like root or a fine branchlet, near the trunk or further away from it, is capable of producing new fibre when stimulated by air, warmth, water and soil nutrients. Manures should not be applied at specified parts of the root system on the supposition that the permanent feeding organs of a tree are located at these spots ; but should be applied with the fact in view that a vastly larger feeding zone could be created by uniformly spreading manures over the entire expanse of the root system. Any manure applied on the unoccupied soil beyond the root zone remains unused till the roots grow and reach the manure. It must be remembered in this connection that manurial elements dissolved in water are carried into the soil with the movement of soil moisture. The movement of water when applied to soil is mainly gravitational and lateral movement by capillarity is limited. Any water that has penetrated down into the soil beyond the reach of roots will remain unutilized by the

tree as the upward flow from the wet soil below to the dry soil above does not take place except where there is a standing water table within 6 to 10 feet of the ground surface (9). Similarly, manures placed beyond the lateral root spread remain unutilized as there is no appreciable lateral capillary movement of moisture.

Broadcasting followed by light harrowing or hand-forking is the best way to apply farm yard manure, especially in the case of surface-feeding fruit trees like citrus, care being taken that no thick roots are damaged in cultivating the soil with implements. Before using inorganic or organic artificial manures it should be ascertained if they readily move with movement of soil moisture or are known for their tendency of slow penetration into the soil. Nitrates move into the soil readily with movement of soil moisture and are at once available to the plant. In well drained soils there is every danger of their leaching away below the main root zone by heavy irrigation. Therefore, while applying fertilizers like sodium nitrate care should be taken to apply them when the rains are light or with moderate irrigation. Nitrogen from fertilizers like sulphate of ammonia, calcium cynamide, nicifos, oilcakes, bloodmeal, fish manures, &c. is not so easily leached. These fertilizers are held firmly by the moist soil and are slowly acted upon by soil micro-organisms and converted into nitrates within a period of 6 to 8 weeks under Ceylon conditions (6).

Phosphates and potash salts penetrate only slowly into the soil and their use by the plants is equally slow. These fertilizers have a tendency to get fixed in the top few inches of the soil though it is likely that if the application is repeated for many years, some of the phosphates and potash will be carried gradually deeper into the soil to a region where they can be absorbed by the roots of the fruit tree. In California phosphates and potash have been shown to persist in the main root zone of citrus trees, *i.e.*, in the first three feet of soil, after a repeated application of manure in moderate amounts for 22 years (2) (8).

It is always a good practice to apply water-soluble artificial fertilizers in irrigation water impounded in basins or check furrows round the tree as this method would allow excellent distribution of soluble nutrients in dilute solution precisely to the feeding root area to which water has been applied.

In the non-irrigated wet zones of Ceylon it is necessary to see that the artificials are deeply forked into the soil as mere scraping in with hand-forks would amount to leaving the manure on the loose soil surface to be easily washed away by a heavy shower.

In the case of deep-rooted trees like the mango, slow-acting phosphate fertilizers and bone manures are best placed in very close vicinity to the roots by removing the top soil down to the uppermost feeding roots. Such manures are more effectively applied in a restricted space by digging a circular shallow trench where the root system is most branched which is somewhere near the drip of the tree crown.

All organic and certain inorganic fertilizers have to be acted upon by certain soil micro-organisms before they become available to the tree. The existence and the multiplication of these organisms depend largely on the presence of humus which is formed in the soil when organic material added to the soil undergoes decomposition. The fertility of orchard soils greatly depends upon their humus content. Soils lacking in humus are invariably poor. Investigations carried out in California and England (2) have proved that there is a rapid loss of organic matter from soils due to decomposition even though relatively large applications are made annually. A liberal annual application of organic bulky manures is, therefore, necessary to maintain soil fertility.

The soil mass is temporarily improved in structure by the addition of green manures or bulky organic manures to the depth to which the soil is cultivated and manured (10). Below that depth the soil maintains its original structure. Therefore, while planting a fruit tree, especially of a deep-rooting habit, its adaptability to a particular kind of soil structure should be well considered, keeping in view the fact that its roots below the cultivated layer will have to adjust themselves to the original and uninfluenced physical condition of the soil.

Cattle dung and farm refuse are the principal sources from which composts are prepared for manuring fruit trees in India and Ceylon, but the materials are not easily available in quantities sufficient to compensate for the loss of organic matter in the soil. To meet this contingency, the practical and cheapest way to add humus is to grow leguminous cover crops and bury them as green manure when they are about to flower. Legumes such as *Crotalaria juncea* and *Phaseolus mungo* would serve as suitable temporary covers during the monsoon in the dry zones of Ceylon. Perennial covers like *Indigofera endecaphylla* should only be grown in wet zones of Ceylon where the rainfall is abundant and well distributed throughout the year.

Slow-acting bulky organic manures are best applied well in advance of the flowering season, while quickly-nitrifying fertilizers should be applied as a top dressing just when the tree is expected to put forth blossom-bearing shoots.

The amount of fertilizer needed by a tree will depend on the age of the tree and the amount of fertility of the soil. There is no

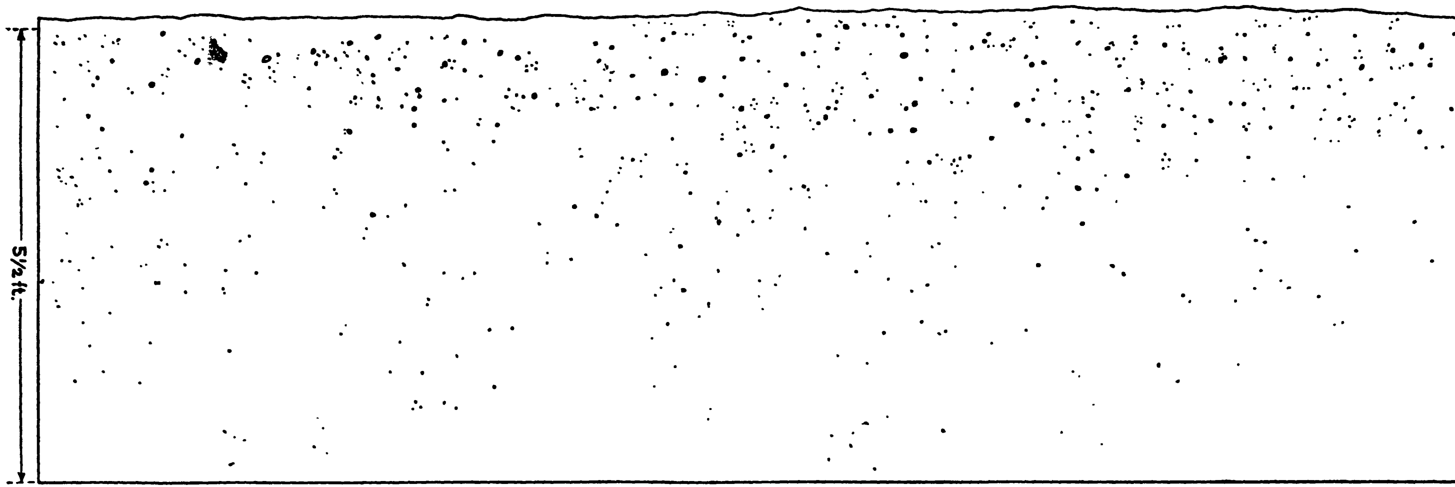

PLATE III.—A VERTICAL SOIL PROFILE SHOWING DISTRIBUTION OF ROOTS OF GRAPEFRUIT (*Citrus paradisi* VAR. *Sicily seedless* ON ROUGH LEMON ROOTSTOCK).

practical way of ascertaining the kind of fertilizer and the quantity needed by the tree except by experimenting under different soil and climatic conditions. Most of the cultivated soils of Ceylon, either in dry or in wet zones, are reported to respond readily to organic manures and nitrogenous fertilizers, but some of them may not appreciably respond to additions of phosphatic and potash fertilizers. Some of the dry zone soils, like those of the Jaffna Peninsula, are rich in lime which is one of the most important plant foods required by fruit trees. On the other hand, the lateritic soils of wet zones are deficient in lime and would need liberal applications of this material with certain fruit crops, *e.g.*, citrus (5).

Cultivation is necessary for the removal of weeds, the proper admixture of manures and for making the soil sufficiently absorptive of water. In the dry zone of Ceylon, groves of trees having sufficient interspace may be tilled in two directions and, if possible, diagonally by means of a bullock-drawn blade harrow soon after spreading bulky manures. It is wise to give very shallow cultivation at the time when the tree is making active growth so as to do least damage to the superficial feeding roots. The damage to roots by cultivation is negligible when the tree is dormant, and therefore it is reasonable to plough or harrow an orchard of bearing trees soon after the harvest is over and when the trees are undergoing a short rest to gather energy for the next flush of growth. To achieve this object the trees should be so treated from the time they are planted in the orchard that their uppermost roots do not come within the range of cultivating implements. As a result of repeated cultivation, the surface soil gets opened out and loses moisture. The tree roots in search of firmer and moister soil, under the circumstacees, will have a tendency to penetrate deeper. Trees thus treated suffer less from severe droughts and build up a stronger and healthier root system than those which are allowed to feed in the most superficial layers of the soil.

It has been shown in California by Veihmeyer (9) that the rate of loss of moisture by the various layers of soil is proportional to the distribution of roots in these layers.

From the chart (Plate III.) it is evident that, although the roots of citrus trees penetrate as deep as $5\frac{1}{2}$ feet, the concentration is much higher in the top layers of soil. About eighty per cent. of the roots are located in the first two feet of soil. It follows therefore that the water supply in these layers will have to be replenished more frequently than in the lower depths where the roots are few and the store of water is abundant.

It has been the writer's experience that in dry soils (common orchard loams) water, when supplied in shallow basins (12 feet square and 6 inches deep) or short cross-furrows (12 feet

long, 16 inches wide from ridge to ridge and 6 inches deep), does not penetrate deeper than 6 to 10 inches even though the soil is well cultivated to a depth of 4 to 6 inches before watering. Apparently, in the case of citrus roots, the ground has to be repeatedly irrigated to moisten the principal root zone of the tree which is located between one and two feet from the ground surface. Great care has to be taken especially when the tree is in fruit not to allow the soil of the main root zone (where most roots have concentrated) to dry out to such an extent as to make the tree wilt.

To secure the best results, according to investigations done by Veihmeyer, the moisture content of the soil has to be kept widely fluctuated between the field capacity, or maximum water-holding capacity, of the soil and the danger point at which the tree begins to wilt (9).

As moisture is removed by the plant roots, air takes its place warming up the soil and making oxygen available to the roots for their rapid growth. Root growth and absorption are retarded if the soil is too wet as a result of over irrigation. Between two irrigations, therefore, wide extremes in soil moisture fluctuations are considered very desirable to allow the greatest movement of air in the soil.

The best method by which the grower can decide when to apply water is by cautiously prolonging the irrigation intervals in a small portion of his orchard and watching the condition of his trees. He should dig out the soil of the principal root zone by means of a soil auger and feel its moisture content with the hand. After a few trials of this kind he will soon become familiar with the degree of soil moisture which would be safe for his trees and the condition of soil dryness which would cause wilting.

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STUDIES ON CEYLON SOILS

XII. SOME CHARACTERISTIC BUT LESS EXTENSIVE SOILS OF THE DRY ZONE

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IN this paper the textural, chemical and profile data of some characteristic soil groups of the dry zone are furnished, and the rough distribution and suitability of the soils for crops indicated. The five soils studied were the black heavy loams of Tunukkai, similar to the black cotton soils of India; the white calcareous loams of Delft Island, of marked similarity to the chalk soils of England; the deep red loams of the Hambantota district and the allied reddish brown loams of the Tangalla district; and the light sandy loams of parts of the Eastern Province. The same methods of analysis as previously were adopted for these soils, with a few exceptions. Readily available Phosphoric acid was determined by the Truog (1) method in all but the calcareous soils for which this method is not applicable. Replaceable bases in the case of one of the calcareous soils were estimated by Williams' (2) method. Calcium carbonate was determined, in addition, in the calcareous soils. The analytical data are shown in table I.

Tunukkai Black Heavy Loam

Location	.. Tunukkai
Elevation ..	.. Sea level
Climate ..	.. Rainfall : 40 in. (approx.) ; temperature 82° F.
Geological origin	.. Felsphatic gneiss overlain by sedimentary limestone in places
Mode of formation	.. Residual
Topographic position	.. Flat
Drainage	.. Imperfect to poor
Vegetation ..	.. Xerophytic scrub jungle ; wood apple

Profile

A. 0->3 ft. .. Black compact heavy loam with nodules of limestone interspersed in places ; reticulate to small clod ; hard and difficultly friable : cracks abundant in dry weather ; streaks of rust brown due to decomposing roots ; root growth confined to upper soil layer.

The characteristic black soil found at Tunukkai village, about 16 miles from Mankulam in the Northern Province, covers a reported extent of about 16 square miles or approximately 10,000 acres. Reference to this soil type was first made in 1921 by Stockdale, Marshall and Bruce (3) in an article in *The Tropical Agriculturist* entitled "Cotton Soils in the Mannar District". From the description, the soils appeared to resemble closely the black cotton soils of India described by Bal (4) and others. The rainfall of the area is probably about 40 inches, practically all of which occurs during the north-east monsoon. The vegetation is typical xerophytic, low scrub jungle. Soil drainage is imperfect, the soil being reported to be somewhat water-logged in the rainy season. The soil, which shows no apparent change in colour, appearance and general characteristics with depth, is from 18 in. to 15 ft. deep. Interspersed within the soil, at varying depths but generally within the first foot, are nodules of limestone of varying sizes. In certain places underlying the soil, slabs of limestone similar to the Jaffna Miocene series occur. The limestone is, apparently, a superficial deposit overlying felsphatic gneiss. In the dry season the soil shows deep cracks of a depth, in places, of 6 feet or more.

The analysis of a typical soil sample shows that it is a heavy loam, poor in organic matter and nitrogen, rich in both available and total lime, and alkaline in reaction. Analysis for total potash and phosphoric acid showed it to contain 0·196 and 0·091 per cent. of these constituents respectively. The soil is, therefore, fairly well supplied with potash, but is somewhat deficient in phosphoric acid. The texture varies to some degree as will be apparent from Bruce's analyses (4). The soil is non-lateritic in nature. The iron content of the clay fraction is low. Bruce found a high percentage of magnesia in the soil and this may account for its stickiness, when wet, and poor drainage.

In respect of its morphological characters, chemical composition and the rainfall conditions under which it has been formed. the soil is similar to the black cotton soils of India. It makes an excellent paddy soil, yields of 60 bushels being reported. and would appear to be quite suitable for cotton, dhal and probably tobacco and chillies. Soil drainage will appear to be necessary. On the deeper soils, provided adequate drainage

is given, fruits like mangoes would probably do well. Successful citrus cultivation is problematic, but if citrus is grown, irrigation would be necessary in the dry season and good soil drainage in the wet season.

Delft Calcareous Loam

Location ..	.. Delft Island
Elevation ..	.. Sea level
Climate	.. Rainfall : 46 in. (approx.) ; temperature : 80° F.
Geological origin	.. Sedimentary limestone (Miocene)
Mode of formation	.. Residual
Topographic position	.. Flat
Drainage ..	.. Good
Vegetation ..	.. Pasture grass, dry grains, palmyrah palms

Profile

A1. 0-9 in.	.. Greyish white calcareous loam ; compact ; cubical to small columnar ; fairly hard but friable ; root growth good ; horizon boundary indistinct.
A2. 9 in - > 3 ft.	.. Similar to A1 but of slightly heavier texture and more compact ; overlying limestone

The greyish-white calcareous loam of Delft Island which is entirely comprised of Miocene limestone occurs only to a limited extent on the Island. It is very closely allied to the *rendzinas* or the chalk soils of Britain. Its texture increases slightly with depth. The soil is poor in organic matter and nitrogen. Phosphoric acid is present in good supply, to judge from the analysis of a sample of pasture grass from the area which showed a phosphoric acid content of 0·83 per cent. against an average of 0·36 per cent. for Ceylon pasture grasses. The soil contains no lesss than 56 per cent. of calcium carbonate and is markedly alkaline in reaction. It is non-lateritic in nature with a silica/alumina ratio of 2·78. Dry grains, leguminous crops and pasture grasses are grown successfully on it. Dhal would appear to be a very suitable crop for the area, and also soybeans and cotton. The pasture, as would be expected, is very rich in lime, a sample being found to contain no less than 3·8 per cent. of this constituent.

Hambantota Brick Red Loam

Location ..	.. 3 miles from Hambantota
Elevation ..	.. About 50 ft.
Climate ..	.. Rainfall : 42 in. (approx.) ; temperature : 81° F.
Geological origin	.. Pleistocene plateau deposits over felsphatic gneiss
Mode of formation	.. Probably transported (aeolian) deposits over residual material
Topographic position	.. Flat
Drainage	.. Very good
Vegetation ..	.. Low scrub jungle

Profile

A.	0- >10 ft.	.. Uniform brick red loam; loose and friable; columnar to irregular prismatic structure breaking down to single grain
C.	10-13 ft.	.. Reddish brown gravelly loam with high proportions of ironstone nodules in various stages of decomposition; pan-like layer formed from decomposing gneiss.

The Hambantota brick-red loam varies in depth from 10 to 30 ft. or more. The soil of the A horizon is uniform in colour and texture and probably derived, in part, from windborne deposits. It is probably also a residual product of hornblende gneiss. The soil of the B horizon is a reddish-brown heavy loam, and is obviously derived from the gneiss. It contains a high proportion of decomposing ironstone nodules and hydrated alumina. The soil is poor in organic matter and nitrogen but has a fair content of bases. The replaceable lime content is only about 50 per cent. of the total bases, suggesting that either the rock is rich in magnesian minerals or that dolomitic limestone has had some influence on the constitution of the soil. In reaction it is alkaline. It is poor in available phosphoric acid and is slightly lateritic in nature. The soil of another profile in the Hambantota district (5) was observed, however, to be of the non-lateritic type. Variations in local conditions are doubtless responsible for this observed difference.

The soil of the A horizon, though a loam, has low cohesive power. Soil erosion of the gully type is very severe at the place the profile was investigated. The extent of these soils is not great and, owing to a deficient rainfall, successful crop cultivation is difficult. They are, however, from the standpoints of texture and depth, very suitable for fruit cultivation.

Middeniya Red-Brown Loam

Location ..	.. Middeniya
Elevation ..	.. About 250 ft.
Climate	.. Rainfall: 67 in. (approx.): temperature: 81° F.
Geological origin	.. Pleistocene plateau deposits overlying felsphatic gneiss
Mode of formation	.. Transported (aeolian) overlying residual material
Topographic position	.. Undulating to slightly hilly; sample from bottom of gentle slope
Drainage	.. Very good
Vegetation ..	.. Citrus and other fruits, rotation crops

Profile

A.	0 - >3 ft.	.. Uniform reddish-brown loam of depth greater than 6 feet in places, overlying loam containing ironstone nodules: fairly hard and compact but friable; irregular columnar; root growth good

This soil appears to be a modification of the Hambantota type, and is similar in many respects to the red lateritic earth of Mullaittivu described in a previous paper (6). It is a deep uniform loam of poor organic matter and nitrogen content and has a carbon/nitrogen ratio of 10·8. In reaction it is alkaline. Its replaceable base content is low, calcium constituting only about 50 per cent of the total. It is also low in available phosphoric acid. The soil is somewhat lateritic in type, with a silica/alumina ratio of 1·8. In origin it is probably a wind-borne deposit overlying residual gneissic material. The soil occurs in fairly appreciable extents in the Tangalla district and vicinity. Physically, it is ideal for fruit crops, particularly citrus, but is equally suited for cotton, dry grain and other rotation crops. Manuring with bulky organics and, where citrus is grown, the periodical application of lime would be necessary.

Kiliveddi Sandy Loam

Location ..	.. Kiliveddi
Elevation ..	.. About sea level
Climate	.. Rainfall : 68 in. (approx.) ; temperature : 82° F.
Geological origin	.. Recent
Mode of formation	.. Transported ; alluvial
Topographic position	.. Flat to gently sloping
Drainage ..	.. Good
Vegetation ..	.. Scrub jungle

Profile

A.	0-14 in.	.. Dark brown sandy soil ; fairly hard when dry but very friable ; single grain ; root growth good ; horizon boundary fairly distinct
C.	14 in.-3 ft.	.. Dark grey sandy loam ; fairly loose and friable ; root growth good

This soil type is typical, in respect of texture, of the forest soils of the Eastern Province. It is a dark-brown, light, sandy loam which increases in heaviness with depth. The lower horizon of this profile contains a high proportion of gravel composed mainly of potsherds, indicating probably that it was the site of human habitation in the past. One other characteristic of this soil is its very high content of readily-available phosphoric acid. It is probable that this is purely local and due to some abnormal factor *e.g.*, the decay of animal remains. The soil is low in organic matter, but strangely enough has a higher carbon content in the lower than in the upper horizon. In reaction the upper horizon is alkaline and the lower slightly acidic. The soil is fairly well supplied with replaceable bases and is of the non-lateritic type. It is at present

being experimentally cultivated with sugar cane under irrigation, and would be very suitable for cultivation with fruits and cashew nuts.

SUMMARY

In this paper the profile and analytical data of five less extensively occurring, but characteristic soil types of the dry zone—the black heavy loams of Tunukkai, similar to the black cotton soils of India, the light grey calcareous loams of Delft Island, similar to the chalk soils of Britain, the brick-red and brown deep loams of the dry, south-eastern parts of the Island, and the light sandy soils of the Eastern Province—are furnished and the suitability of the soils for crops discussed and their rough distribution indicated.

TABLE I.

	Tunukkai	Delft		Hambantota		Middeniya	Kiliveddi	
	A	A	C	A	C	A	A	C
	%	%	%	%	%	%	%	%
Mechanical Analysis								
Stones and gravel	10·1	nil	nil	nil	12·7	nil	3·4	23·5
Coarse sand	24·9	—	—	45·3	34·1	38·5	44·1	48·2
Fine sand	22·4	14·7	7·3	22·8	19·7	28·1	37·5	30·6
Silt	8·9	2·9	2·8	3·3	5·0	4·1	5·4	6·4
Clay	31·7	17·2	21·9	25·1	34·1	27·2	10·3	11·7
Loss by solution	6·1	61·1	62·6	1·1	2·6	0·5	0·9	1·0
Moisture	6·0	4·1	5·4	2·4	4·5	1·6	1·8	2·1
Texture index number	29·5	15·7	20·2	23·0	31·3	25·0	9·8	11·3
Soil type	Heavy loam	Light loam	Loam	Loam	Heavy loam	Loam	Sand	Sandy loam
Chemical Analysis								
Loss on ignition	5·12	16·90	12·06	3·73	4·06	4·02	2·67	3·64
Combined water	4·24	15·52	11·29	2·94	3·48	3·21	1·04	1·14
Organic matter	0·86	1·38	0·77	0·79	0·58	0·81	1·63	2·58
Carbon	0·505	0·803	0·449	0·458	0·336	0·469	0·943	1·50
Nitrogen	0·069	0·094	0·050	0·044	0·034	0·043	0·069	0·073
Carbon/nitrogen ratio	7·40	8·56	9·00	10·58	9·88	10·85	13·67	20·55
Reaction (pH)	8·6	8·4	8·4	8·1	8·1	7·9	7·7	6·4
Total exchangeable bases (m.e. per 100 gm. soil)	76·5	—	—	6·01	6·49	4·11	8·89	7·72
Exchangeable calcium	43·3	—	—	2·99	3·15	2·09	7·49	5·61
Readily available phosphoric acid (mgm. per 100 gm. soil)	—	—	—	0·59	0·46	0·43	35·5	27·6
Calcium Carbonate	3.64	56·73	58·14	—	—	—	—	—
Clay Analysis								
Loss on ignition	23·36	19·79	—	20·33	19·54	18·76	18·41	—
Silica (SiO_2)	53·12	51·02	—	41·58	43·04	43·08	52·76	—
Sesquioxides (R_2O_3)	37·10	39·35	—	55·85	51·60	51·55	34·95	—
Alumina (Al_2O_3)	31·98	31·12	—	40·68	38·46	40·26	18·29	—
Iron oxides (Fe_2O_3)	5·12	8·23	—	15·17	13·14	11·29	16·66	—
SiO_2/Al_2O_3 (molecular)	2·81	2·78	—	1·74	1·89	1·81	4·90	—
SiO_2/R_2O_3	2·56	2·38	—	1·40	1·55	1·54	3·09	—
Soil type	Non-lateritic	Non-lateritic		Lateritic		Lateritic	Non-lateritic	

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THE EFFECT OF MANURING ON THE INCIDENCE OF CHILLI LEAF-CURL

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THE information available with regard to the nature of the complex of diseases of chillies (*Capsicum frutescens* L.) commonly included in Ceylon under the name leaf-curl, is meagre. Park and Fernando (1938) investigated the etiology of a type of chilli leaf-curl characterized by the abaxial curling of leaves and the necrosis of apical meristems ; the evidence advanced by these workers suggested that the particular type of leaf-curl studied by them was the result of direct insect injury, the causal insect being possibly a thrips, a mite or an aphid. The leaf-curl disease which is extensively distributed throughout the chilli-growing areas in the dry zone and which forms the subject of the present communication, exhibits somewhat different symptoms and is probably due to some cause other than that which is responsible for the previous type of leaf-curl. The margins of affected leaves in the leaf-curl disease reported in this paper curl in adaxially, and the failure of the veins to keep pace with the extension of leaf surface results in buckling of intervenous areas, which appear deeply concave on the under side of the leaf. Considerable reduction is shown in the size of affected leaves, a feature which this disease shares with the malformation described by Park and Fernando (1938). In this instance, however, there is no necrosis of apical meristems, but the internodes fail to reach their maximum length and the plants present a bushy appearance, while the fruits remain small and malformed.

The experiment described below had been designed and laid down at the Experiment Station, Jaffna, during the *yala* season of 1938, by Dr. A. W. R. Joachim, Chemist, Mr. S. K. Thuraisingham, Sub-Divisional Agricultural Officer, Jaffna, and the senior author, for the purpose of investigating the effect of different manurial and picking treatments on the yield of

chillies. In view of the appearance, in the experimental area, of a severe epiphytotic of leaf-curl, it was believed that the leaf-curl data in the experiment would prove a valuable contribution to our knowledge of this disease, the nature of which is still obscure.

DESIGN OF THE EXPERIMENT

Treatments.—Details of the three sets of factors which consisted of the application of nitrogenous and farmyard manure at three and two levels respectively, and two types of picking of pods, are given in Table I. The design was factorial, *i.e.*, it included all possible combinations of the three sets of factors. The picking treatments were unlikely to affect the occurrence of leaf-curl, but were retained in the statistical analysis as dummy treatments.

System of Replication.—The twelve treatments were randomized in six blocks of six plots each. Certain interactions were partially confounded with block differences.

Size of Plot.—Each plot was 1/54 acre (39 by 21 ft.) and contained seven rows of 13 hills, spaced 3 ft. between and within rows. An edge row of plants was rejected in the collection of data and a strip $1\frac{1}{2}$ ft. wide was allowed for outside the edge row. The nett area contributing data was hence 1/121 acre (30 by 12 ft.) and consisted of five rows of eleven hills.

TABLE I.

Application of Nitrogenous Manure.	Application of Farmyard Manure.	Picking.
NO : nil	FO : nil	PO : pods picked red throughout
N1 : one dressing of $2\frac{1}{2}$ lb. nitrate of soda per plot (20 lb. nitrogen per acre)	F1 : $1\frac{1}{2}$ cwt. farm-yard manure per plot. (4 tons per acre)	P 1 : pods picked green at first picking ; all subsequent pickings red
N2 : 2 dressings, each of $2\frac{1}{2}$ lb. nitrate of soda per plot (40 lb. nitrogen per acre)		

EXPERIMENTAL MATERIAL AND METHODS

Experimental Area.—The soil was a red, calcareous loam well supplied with phosphoric acid and potash, but rather deficient in nitrogen and organic matter, and it had an alkaline reaction. The area carried the following crops in previous seasons :—

March, 1937–July, 1937 : melons and pumpkins.

October, 1937–November, 1937 : sunnhemp grown as a green manure and turned into the soil.

December 1937–March, 1938 : tomatoes.

At the time of transplanting, the experimental site was bounded on the northern edge by a path which separated it from an old area of chillies severely affected with leaf-curl. There was a windbreak of gliricidia on the northern, and small plots of brinjals, sweet potatoes, cabbages and plantains on the western border. The land on the east was also planted with chillies at about the same time as the experimental area and may, for certain purposes, be considered continuous with it.

Cultivations, &c.—The area received no basal manuring. It was ploughed on April 2 and 6, and May 2, and harrowed on May 3. The farmyard manure was applied to the plots receiving it on May 26. The nurseries were sown on April 4 and the seedlings planted out on May 27 and 28, two seedlings being used per hill. Irrigation was carried out on eighteen occasions during the months of May, June and July. Weeding and intercultivation operations were performed during the period June 14 to 16. Nitrate of soda was first applied (N 1 and N 2 plots) on June 16, the manure being spread around the base of the plants and forked in. The second application of nitrate of soda (N 2 plots only) was made on July 18. The area was again weeded and earthed up during the period June 28 to 30.

METEOROLOGICAL DATA

Relevant rainfall records are presented in Table II. The records were made at 9 a.m. each day for the previous twenty four hours. Days of no rain are omitted.

TABLE II.

Daily rainfall records for the months April-September, 1938.

Date		Rainfall in.	Date		Rainfall in.
April	2	0·72	April	31	1·18
	3	0·33	May	11	1·68
	4	0·23		31	1·18
	5	0·02	June	1	0·04
	9	0·60	July	27	1·96
	10	0·08		28	0·20
	12	0·08		29	0·25
	14	0·12		31	0·91
	16	0·10	August	14	0·65
	18	0·11	September	14	0·55
	20	0·32		19	0·05
	21	0·01		22	0·29
	27	1·37		23	0·02

RESULTS

Records of leaf-curl made on August 3 and September 23 are presented in Fig. 1. The crosses represent plants that were healthy at the time the second record was made, and the solid black squares the plants that had shown leaf-curl symptoms at the time of the first record. The white squares indicate plants that had been unaffected at the time of the first record, but exhibited symptoms at the time of the second record. A feature of the records was the absence of any indication of recovery of affected plants; there were no instances of plants which had been diseased at the time of the first record and were clean at the time of the second, though competent observers in Jaffna claim that affected plants often recover.

The percentage of affected plants in the experimental area, at the time the second record was made, was as high as 87 per cent. The data in the second record were, after rejection of border rows, subjected to an analysis of variance. The value of F for treatments did not reach the five per cent. point and hence was not indicative of a significant effect. The experimental error was low, *viz.*, 10·5 per cent. of the general mean. It might accordingly be argued that the applications of nitrogenous and farmyard manure had no influence on the occurrence of leaf-curl. The numbers of diseased plants in the various treatments are given in Table III. It should be noted that the area did not receive any basal manuring and that it had been initially poor in nitrogen and organic matter but rich in phosphoric acid and potash. The absence of any response to nitrogenous and farmyard manuring is hence of special interest. Deficiency in soil nitrogen can thus be eliminated from the list of possible causes of chilli leaf-curl. The improvement in soil fertility and soil texture consequent on the addition of the much needed organic matter was not accompanied by any reduction in the severity of leaf-curl. Farmyard manure is, *inter alia*, rich in phosphoric acid and potash, but the soil had been initially well supplied with these compounds and no conclusions can hence be drawn concerning them.

TABLE III.

Number of plants affected with leaf-curl

	N 0	N 1	N 2	Total
F 0	285	300	267	852
F 1	280	294	300	874
Total	565	594	567	1,726

The distribution data in Fig. 1 are inadequate for purposes of application of the binomial and geometric series tests developed by Cochran (1937). There is, however, a suggestion of border infection in the first record, the incidence being highest

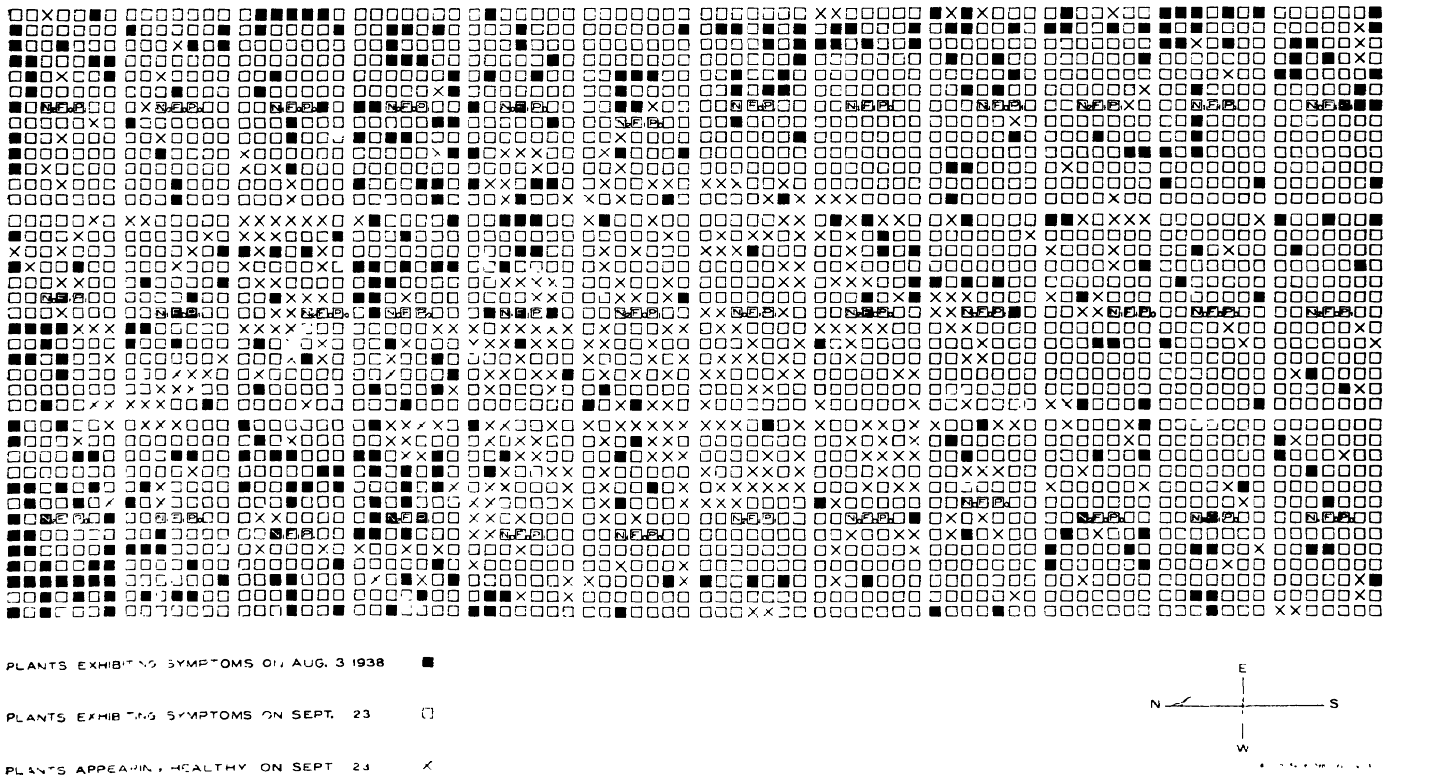

FIG 1.—AREAL DISTRIBUTION OF CHILLI PLANTS AFFECTED WITH LEAF-CURL.

on the northern border which, it will be remembered, was adjacent to an old crop of chillies severely affected with leaf-curl. At the time of the second record, *i.e.*, seven weeks after the first record, the distribution of affected plants was still not completely at random. There is no marked evidence of neighbour infection, although there are slight indications of a tendency of affected plants to cluster in groups. Analogy with the type of leaf-curl investigated by Park and Fernando (1938) suggests that this disease too may possibly be of insect origin, and the distribution data are in keeping with a theory of damage by an organism with limited powers of locomotion, entering the experimental area from outside, *e.g.*, a weak-flying insect. At this stage any speculation on whether the insect postulated produces direct injury or whether it is merely the vector of a virus disease, is of course premature. If the disease happens to be of insect origin, the fact that nitrogenous and organic manures do not affect the resistance or the susceptibility of chillies to insect attack, would be of considerable interest.

SUMMARY

A type of leaf-curl which is different from that previously described in Ceylon, occurs in the dry zone and is characterized by the adaxial curling of the margins of affected leaves and the buckling of intervenous areas. Affected leaves remain small and the fruits are malformed.

Records of the numbers of leaf-curl plants were made on two occasions, with an interval of about seven weeks, in the plants of a factorial experiment carried out at Jaffna, to compare the effects of nitrogenous and farmyard manures on the yield of chillies. Analysis of the data showed that deficiency of the soil in nitrogen and in organic matter could be eliminated as possible causes of leaf-curl.

Examination of the distribution of affected plants suggested the possibility that insects were responsible, either directly or as the vectors of a virus disease.

ACKNOWLEDGMENT

The writers express their thanks to Mr. S. K. Thuraisingham, Sub-Divisional Agricultural Officer, Jaffna, and Mr. S. Balasingham, Manager, Experiment Station, Jaffna, for their assistance in keeping the records of leaf-curl plants.

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CHILLI LEAF-CURL EXPERIMENTS

.—PRELIMINARY INFECTION TESTS

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TILL recently, the condition known as leaf-curl in chilli plants in Ceylon was suspected to be of virus origin. Park and Fernando (1938), however, questioned the virus nature of the affected plants and suggested that thrips, mites or aphids were responsible for the damage. Accordingly a number of affected plants from both Peradeniya and Jaffna was examined. In every instance thrips, mites and aphids were found. In this paper are reported the results of an experiment carried out to determine which, if any, of these insects was responsible for the damage.

Six-weeks old chilli seedlings of the Tuticorin variety were transplanted in pots and were allowed to establish themselves for about ten days. Soil of the same composition, both chemical and physical, was used in all pots and this was obtained from a heap which was thoroughly mixed prior to filling of the pots. The plants were then sprayed, in order to free them from the insects under observation, with a nicotine sulphate mixture made up as follows :—

Nicotine sulphate (Nicotine 40%)	⅓ oz.
Soft soap	1 oz.
Water	1 gallon

The spray was applied freely on the leaves and surface soil of the pots and also on all exposed areas of the pots themselves. Immediately after spraying, the pots were enclosed in cloth cages (Plate I.) of very fine texture and were kept in the open throughout the experiment. Each pot with the cage was rendered proof against both crawling and flying insects. The plants were watered through an aperture on the cloth cage. This aperture was kept closed up, except for a minute or less, during the process of watering and every endeavour was made to do this as quickly as possible to obviate the possibility of introducing other insects.

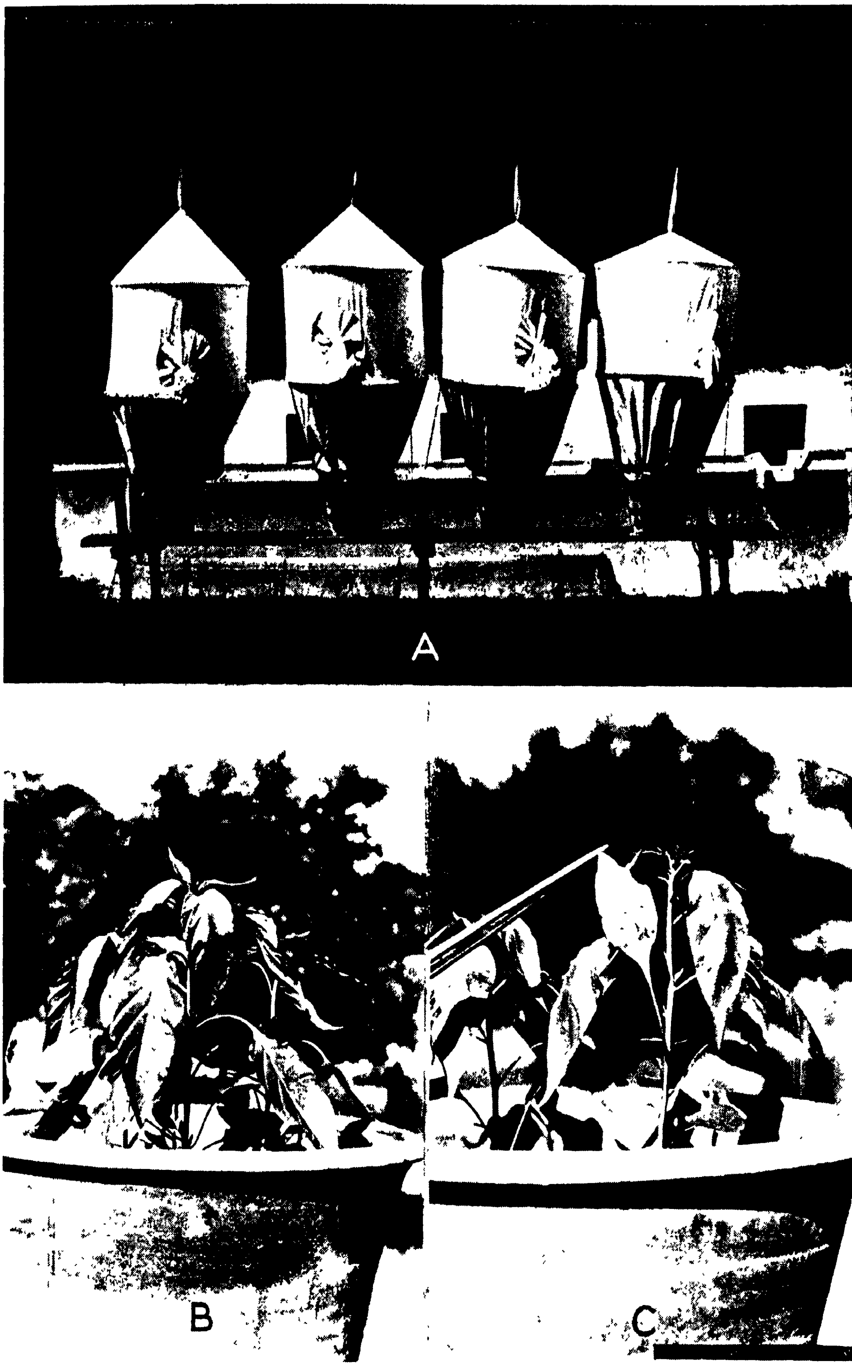

PLATE I.—A—GENERAL VIEW OF THE POTS WITH THE CLOTH CAGES.
B—HEALTHY CONTROL PLANT.
C—PLANT INFESTED WITH APHIDS.

PLATE II. PLANT SHOWING CRINKLING AFTER INTRODUCTION OF THRIPS.

A total of seven pots was used for this experiment and the insects and mites were introduced seventeen days after the plants were sprayed. All plants at the time of introduction were quite healthy and exhibited normal growth. Mites collected from affected plants obtained both from Jaffna and Peradeniya were transferred to the seedlings in two pots, each pot containing the introduction from one area. Aphids were introduced into two pots and thrips into one. The aphids and thrips were collected only from affected plants received from Jaffna. Two pots contained no insects whatever and these were used as controls. In the process of transferring the insects from the affected plants to the healthy seedlings in the cage every care was taken to prevent the possibility of contaminating the latter with any plant juice or plant product from the former. This was achieved by picking out the insects with a fine camel hair brush under a binocular microscope and transferring them to leaves of healthy plants which had been previously subjected to the nicotine spray mentioned above and placed in cages similar to the potted plants. These leaves with the insects were then placed on the plants in the cages.

The plants were examined daily for any malformation of the leaves and the first symptoms of curling were noticed in the pot containing thrips about a week after the introduction. The tender young leaves in this instance exhibited typical signs of crinkling. The plants in the other pots remained completely healthy. Five days later the curling had become very pronounced and involved all new leaves which had been put out since that date. Plate II. illustrates the affected portion thirteen days after introduction of the thrips. Cherian (1936) records the leaf-curl of chillies in India as being due to the attacks of *Scirtothrips dorsalis*, Hood., but whether the thrips responsible for the diseased condition in Ceylon is the same as the one in India cannot be said with certainty at present.

SUMMARY

1. Chilli plants affected with leaf-curl were found to be infested by thrips, aphids and mites.

2. An attempt has been made to incriminate the insect responsible for the damage.

3. A species of thrips has been found to bring about a malformation of the leaves.

ACKNOWLEDGMENTS

The author's thanks are due to Mr. W. R. C. Paul, Acting Plant Pathologist and to Dr. M. Fernando, Research Probationer in Plant Pathology, for helpful suggestions and to Mr. E. de Alwis, Assistant in Entomology, for useful assistance.

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DEPARTMENTAL NOTES

THE SUPPLY OF VEGETABLE SEEDS FROM DEPARTMENTAL SOURCES

THE sales of seed at the Seed Store of the Department of Agriculture which was closed in April, 1937, were of three kinds—seeds of flowers and English vegetables, seeds of green manures and seeds of local vegetables. Seeds of flowers and English vegetables and of green manures can be bought from commercial seed merchants and from the large stores, and it was considered undesirable that the Department of Agriculture should compete with these firms. The supply of indigenous vegetables at the Seed Store was not satisfactorily organized; the system adopted was to buy vegetable seed in bulk from local growers, to clean and test it for viability, and sell it in small packets. Thus the purchaser had a guarantee of the quality of the seed itself, but no guarantee of the quality of the produce that grew from it.

Since the Seed Store was closed, three experiment Stations have been opened where local vegetables are being grown and tested. One is at Tabbowa, near Puttalam, one is near Batticaloa and the third is near Matale. It is proposed to determine which is the best locality for growing each kind of vegetable, and to select good strains for the production of seed, so that when vegetable seeds are sold, it will be possible to give some assurance of the quality of the vegetables that will grow from the seed.

The selection of high yielding varieties of superior quality vegetables is a slow process, entailing as it does the growing of crops and the selection and trial of the best plants, with a vigorous elimination of any selections that prove to have undesirable characteristics such as undue susceptibility to disease. It is not proposed to offer seed for general sale, except in a time of emergency, until the selection work has reached an advanced stage. It is hoped that supplies of such seeds will be available for issue in three years' time.

The following vegetables are under trial:—Brinjal, Snake Gourd, Bottle Gourd, Bitter Gourd, Cucumber, Luffa, Bandakka, Tomato, Cowpea, Capsicum.

2——J. N. 1044 (2/39)

DISTRIBUTION OF POULTRY IN THE VILLAGES. AN EXPRESSION OF GRATITUDE

One of the features of the Work of the Department of Agriculture in villages which have been selected for special attention and which are known as "development areas" is the encouragement of an improved standard of poultry keeping. To this end, settings of eggs and purebred cockerels are issued to villagers with the object of grading up the local poultry and of increasing egg production both in quantity and quality.

In one of the development areas in the North-Western Division this work has been assisted by the action of a public-spirited gentleman residing in the locality who presented a number of pure-bred R.I.R. cockerels for distribution among the villagers in the area. It is felt that this public-spirited action should be given some publicity since it provides an example of a simple way in which members of the general public can assist Government in its attempt to improve the standard of husbandry in the Island.

REGULATIONS REGARDING THE IMPORT OF FRESH FRUIT INTO CEYLON

On 30th September, 1938, new regulations under the Plant Protection Ordinance, No. 10 of 1924, were published in the *Government Gazette.* Some of these regulations are of general interest and it is felt that a short explanatory note will help members of the general public to understand why the regulations were introduced and also may help to prevent unnecessary inconvenience to those who wish to import small quantities of fresh fruit.

The regulations are, in general, those which have been in force for some years and which are imposed with a view to preventing the introduction into Ceylon of undesirable pests and diseases. There is, however, one noteworthy addition in regard to the import of fresh fruit and this regulation has as its main object the exclusion from Ceylon of the Mediterranean Fruit Fly (*Ceratitis capitata*). The introduction of this regulation became necessary when certain consignments of oranges were examined in Colombo and were found to be heavily infested with the fly.

The Mediterranean Fruit Fly is a serious pest of fruit which has been recorded in the Mediterranean countries and in certain other parts of the world, notably South Africa, Queensland, New South Wales and Western Australia. The fly is capable of attacking a wide range of fruits and vegetables and is so destructive that it was felt that every possible step should be taken to exclude it from Ceylon. The fly pierces fruits by means of its long ovipositor and lays its eggs within them. The eggs hatch out into maggots which eventually cause a soft, stinking rot of the fruits. In the early stages it is difficult, if not impossible, to distinguish by casual examination those fruits which are infested. Moreover, as the eggs and grubs are inside infested fruits, disinfection by fumigation does not kill the pest. It follows that the usual practice of inspecting consignments of fruit and, if necessary, of fumigating them does not serve as a means of preventing the introduction of the pest in infested fruit. It has, therefore, been necessary to introduce a system of licences to import fresh fruit into Ceylon.

Licences to import fesh fruit from countries in which the Mediterranean Fruit Fly has not been recorded can be obtained free on application to the Director of Agriculture. The countries from which imports of fresh fruit into Ceylon are made and which are considered to be "free" countries include India, Burma, Malaya, United States of America, South Australia, Victoria and New Zealand. The only condition attached to the import of fruit covered by the licences is that the fruit should have been grown in the country from which it is exported and that it should be consigned direct to the licence holder. Licences can be obtained to cover the import of one consignment of fruit or, alternatively, to cover consignments of all the types of fruits specified in the licence, for a period of one year. Residents of Ceylon who wish to import fruits from India or from the "free" countries are advised to apply for licences, stating the varieties of fruit it is desired to import and the country from which it is desired to import the fruits. The licences can either be used personally when clearing the packages at the Colombo Customs or can be sent with a covering letter to the accredited agents in Colombo.

As a further means of control, the import of fresh fruit in Ceylon is prohibited except through the Port of Colombo.

BEE-KEEPING NOTES

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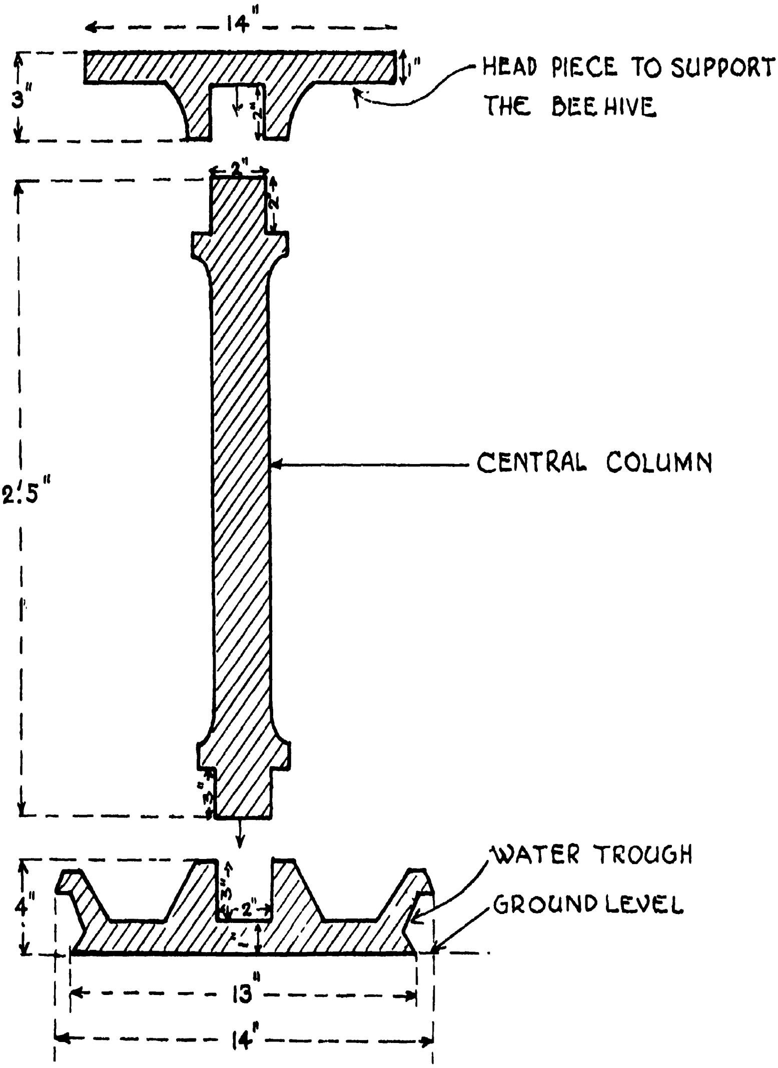
A NEW STAND FOR BEEHIVES

SUCCESS in bee-keeping is largely dependent on the vigilance of the bee-keeper in protecting his bees from such enemies as lizards, cockroaches and ants that damage the combs, eat the honey and destroy the bees, ultimately weakening the colony considerably. In Harispattu, a formidable enemy of bees is *Cremastogaster dohrni*, (*S. Kodaya*). These tiny black ants are generally found on trees but often enter bee-hives and construct their greyish-black, pulpy nests within, with the ultimate result the colony of bees vacates the hive in favour of the intruder. Owing to these crawling enemies, it has been found that, in Ceylon, it is necessary to provide a stand for bee-hives which will prevent the entry of these creatures into the hives. The simplest method of excluding these pests is to surround the post supporting the hive with a trough containing water. This can be achieved by standing a simple wooden post in a trough of water or by constructing a stand of the type described in *The Tropical Agriculturist*, Vol. LXXXIX., page 373, December, 1937, which consists of a metal stand with a galvanized tray containing water, fixed about a foot above ground level. These stands have not been found to be entirely satisfactory. Wooden posts tend to rot in the course of time and galvanized water trays sooner or later become corroded and leak. It is, therefore, necessary to renew or renovate these stands periodically. It is suggested that a more permanent stand of the type described below, although it is a little more expensive, will prove to be more economical in the long run.

The stand is made entirely of concrete and consists of three parts :—the water trough, the central column and the head-piece or platform (see sketch). The water trough is built 13 inches square at the bottom with sides slanting upwards and outwards, with a slope of one inch in three inches. The trough is 2½ inches deep, and is provided with a socket in the centre. The



CONSTRUCTION OF CONCRETE BEEHIVE STAND

BLOCK BY SURVEY DEPT. CEYLON. 7 1 39

column is built square with shoulders at each end to ensure perfect fitting of parts and is 2 inches thick and 2 ft. 6 inches long. The platform for supporting the bee-hive consists of a rectangular slab of concrete, measuring 14 inches by 9 inches and one inch in thickness, and is also provided with a socket in the centre on the under side. Each part is turned out in a wooden mould. The platform and the water trough are both reinforced with a sheet of expanded metal, while the column is reinforced with five strands of barbed wire running lengthwise. The stand, fully assembled, is 3 ft. in height, weighs about 40 pounds and can be turned out at a cost of Rs. 2. In assembling the stand, one end of the column is inserted in the socket provided in the water trough, while the socket of the head piece is slipped on to the top free end of the column. The stand is attractive in appearance and should add to the charm of any garden in which bee-hives are placed.

SOIL CONSERVATION*

EROSION ON CULTIVATED LAND

Types of Erosion.—Erosion on cultivated land takes place in two main forms: (1) sheet erosion, and (2) gully erosion. Sheet erosion, as its name indicates, consists of a skimming off of the surface, a fraction of an inch at a time, and is therefore often invisible, a fact which deceives many farmers when they state that they " lose nothing at all by erosion ". Actually, sheet erosion occurs on practically every cultivated land, even though apparently flat, and is all the more dangerous for being invisible, so that the unhappy owner is made aware of his loss only by a gradual decline of crop yields. An inch of rain will carry off a ton or more of soil per acre, and this silt will obviously contain a larger amount of the lighter elements, such as humus and soluble plant food, than a ton of soil in its original position. For this reason the soil deteriorates in texture as well as in depth and fertility, and requires an excessive amount of green-manuring and fertilizing to make good its losses.

Gully erosion is more spectacular and causes very heavy local losses through the spread of lateral branches. The area affected widens annually in this way, and lengthens as the head cuts back to the land above, while the gully itself becomes deeper and wider until it is impossible for a plough to cross. Many broad lands have been cut up and spoilt in this way, and if neglected too long the gullies may be beyond reclamation, although they may be controlled. If taken in time, however, they may be blocked and crossed by contour ridges. The longer a badly-gullied land is neglected, the more expensive it becomes to protect. Gully erosion will frequently develop from sheet erosion, through concentrated flow in any depression or channel, natural or artificial.

Factors which Influence Erosion.—The rate of erosion is dependent on several factors, some of which are natural, and therefore largely uncontrollable, while others are artificial, and therefore, controllable, but there is often no hard and fast distinction, so that one farm which has natural disadvantages may be maintained in good heart by intelligent farming practice while another, which is well favoured, may be ruined by mistaken methods.

Natural factors :—

(1) Rainfall intensity.

(2) Slope and contour of land.

(3) Character of soil (chemical composition, texture, permeability, &c.).

* Extracts from the Rhodesia Agricultural Journal, March, 1937, Vol. XXXIV., No. 3.

Artificial factors :—

(1) Methods of working (ploughing, harrowing, planting, &c.).
(2) Crops and rotation.
(3) Humus content (green-manuring, &.).
(4) Selection and size of land.

Rainfall Intensity.—In sub-tropical countries, such as Southern Rhodesia, the rainfall tends to become erratic and violent, which explains why erosion is so serious in this country and practically unknown in temperate climates such as in England. If this is true of the country as a whole, it is even more pronounced in the case of a small area, such as a cultivated land, which is subject to purely local storms of very severe intensity. A rainfall of 3 inches in an hour must be regarded as of common, almost annual, occurrence, and storms reaching a rate of 6 to 8 inches per hour have been recorded. Every increase in the amount and intensity of rainfall causes a larger increase in the amount of run-off. An increased volume of run-off means an increased velocity. If the velocity is doubled, the capacity of the water to transport soil is multiplied 64 times.

Rainfall intensity is beyond human control, but these facts illustrate the necessity not only of protecting cultivated land but also of making the protective works amply strong to withstand our severe conditions.

Slope and Contour of Land.—It is a matter of observation that steep lands will erode more rapidly and severely than lands of gentle slope. The contour is also of importance, since a steep land containing depressions will erode more rapidly than one of even slope. These statements sound sufficiently obvious, but should be remembered before opening new lands on steep slopes. In general it may be said that no land steeper than 1 in 15 should be planted to field crops.

Character of Soil.—Soils vary greatly in their resistance to erosion. To a large degree this is due to differences in permeability, since a tight clay soil, or one with an impervious sub-soil, quickly becomes water-logged, and the subsequent rainfall, being unable to penetrate, produces a heavy run-off. This factor is therefore a direct cause of erosion. It is not confined to heavy clay soils, and it is quite common on certain types of sand veld, which appear absorptive, but are shallow and have a dense clay sub-soil. Impervious soils and sub-soils therefore produce high rates of run-off, especially if puddled through being worked when wet, and require contour ridges at closer intervals than normal.

Soils and original vegetation also differ through a natural adaptation by Nature to climate, and for this reason soils in very wet zones have more resistance to erosion, often because of a higher humus content, than those in arid territories.

The actual "erodibility" of a soil depends on hidden characteristics which can only be gauged by physico-chemical analysis, and for that reason cannot be dealt with in a general discussion.

Suffice it to say that the character of a soil will deteriorate seriously under the action of erosion and bad farming, and the loss of humus and the lighter top soil will render a land, originally friable, liable to "pack" and water-log and plough up into great clods.

Methods of Working.—Correct cultural methods, from the point of view of erosion control, should be aimed at keeping the soil in good condition and encouraging rainfall to penetrate *where it falls.*

An elementary example of what is to be avoided, but one that is still too commonly seen, is the practice of ploughing and planting downhill. Every furrow down the slope is a potential gully. There are lands which have a series of straight parallel gullies every 30 to 40 yards, which are due to no other cause, and are too big to be crossed by implements. When once a land has started to erode in this way the pace rapidly accelerates, and the land becomes poor and unworkable. Contour ridges on a land so cut through with gullies need to be much closer together than on uneroded lands, as the old washes silt up and cause the ridges to break, and are also more expensive owing to the amount of building up required at each crossing. By ploughing and planting on the contour every crop-line acts as a miniature contour ridge, and gives the rain a chance to soak in. Deep ploughing is also beneficial, as it provides a greater depth of loose, and therefore absorptive, soil. Every drop of water absorbed decreases the amount of erosion and stands the crop in good stead during a drought, and in a wet spell reduces the tendency to waterlog.

For the same reason every effort should be made to avoid packing and puddling the soil, especially if of a heavy type. Many farmers cease cleaning and allow weeds to grow when mealies are 3 to 4 feet high, with the idea of preventing erosion, but they forget that the greatest damage is done before the mealies or weeds are high enough to form a dense cover. Moreover for this or other reasons the land will require repeated harrowings and cultivations the following year, which pack the soil and lead to the formation of a smooth surface crust that is not absorptive and causes further erosion. The excessive harrowing rendered necessary increases erosion and run-off, reduces absorption and later makes ploughing difficult, and results in great clods which will require soaking rains and further excessive harrowings to break them later. Not only does all this add to the expense of farming, but extra hoeing is required to keep down the weeds which have seeded. Inter-planting with a close-growing cover-crop has all the benefits and none of the objections, and should be practised instead.

The soil should never be worked when wet, as this leads to puddling, and by packing the particles of soil closely together the land becomes impervious, which may take years to remedy.

Crops and Rotation.—Erosion is most severe with a clean-tilled crop, that is with plants widely spaced and with bare ground between, such as maize, cotton, tobacco, sun-flowers, &c. Losses of water and soil are greater with crops of this sort than with a low or close-growing cover-crop. For this reason,

continuous maize is to be deprecated, and a proper rotation preferred. A season under sunnhemp saves the soil as well as enriches it. The rotation of grasses with tobacco is dealt with later.

Humus Control.—One of the chief factors which reduce run-off and erosion and increase absorption is the amount of humus and fibre present in the soil. When these are completely lacking, erosion can be controlled only by very closely spaced contour ridges. A soil in good heart and containing plenty of humus is easier to work, it absorbs more water and the surface does not pack.

Selection and Size of Land.—There are two situations which should be avoided. One is the middle of a vlei, and the other is a steep hillside. The cultivation of vleis is a great temptation, as the land is open and requires no stumping, but the practice, which was common on many of the older farms, is a disastrous one and has led to the formation of awe-inspiring gullies. The middle of a vlei is the natural water-course, and should always be left as a strip of untouched vegetation, which should be added to by planting other grasses if necessary, and treated as a paddock if suitable, but on no account should it be ploughed. In a vlei that has already eroded, the gully should receive treatment and a strip of 10 to 20 yards on each side should be left unploughed or planted to grass.

Vleis are the natural grazing areas because they retain moisture longest, and it is better to use them for this purpose and plant grasses of good feeding value rather than to put them under cultivation and expose them to the certainty of erosion which will quickly ruin them and make them not only unsuitable for any useful purpose but will also drain moisture and soil from the rest of the farm. Most crops will be found to do better where the timber was heaviest, and although the initial expense of stumping is greater these areas are easily protected and can remain permanently under cultivation.

Ultra-steep lands should also be avoided. Erosion is so rapid on steep slopes that these lands are very quickly ruined and are expensive and difficult to protect. It is a short-sighted policy to stump a land in the hope that two or three years of cropping will pay for it, because such a land is expensive to work and the crop (and the land) may be ruined in the first year by a sharp storm. Far better to contour ridge it as soon as it is stumped, and put it down to a plantation, orchard or permanent pasture. If initial protection is neglected the paddock will be useless for mowing purposes, because of the numerous small gullies formed betore the grass got a hold.

Steep hillsides and the bottoms of vleis are uneconomical for cultivation, because the cost of working and protection is far too high in proportion to the yield of crops, and before long there is nothing left but a mass of gullies or a deep donga which are eye-sores that lower the value of a farm and are sources of difficulty and loss.

A further point in connection with the size of land is that lands in very large blocks will suffer from erosion, even if almost flat, merely because of the excessive volume of water collected on them. For tobacco, particularly,

it pays to open a number of smaller blocks of land separated by natural bush or plantations. These small lands are easier to protect from erosion, better sheltered from wind, and reduce the risk of total loss from disease or hail.

Summary.—Much can be done to prevent erosion, in spite of unfavourable natural conditions, by recognized good farming practices, but excess water must be controlled by drains and ridges, and even when the land is completely protected these good farming practices are still most necessary. Conservation measures and good farming should go hand in hand. Much fertilizer is wasted on eroding lands. Contour ridges conserve plant food and moisture but they do not manufacture them.

CONTOUR RIDGES

Objects and Functions—Contour ridges are known by many names, contour drains, contour banks, Mangum terraces (after the name of their American originator) and ridge terraces. Any reference to "drains", however, is misleading, because the correct type of construction consists primarily of a broad ridge, and a defined channel is not required. Ridges consist of long, low, broad banks of earth running almost on the level across the slope of the land.

As previously stated, the greater the volume of storm water flowing over a given land the greater the erosion. By constructing contour ridges the land is divided into long narrow strips, and the total amount of storm-water is therefore divided into small volumes which are more easily controlled. Moreover, as the water has but a short distance to run between one ridge and the next, it has more chance of soaking in and less chance of picking up soil. Such little soil as is carried by this water is mostly deposited when it is checked by the ridge, and a very small fraction is lost. Formerly it was considered that one of the most desirable objects of contour ridges was to silt up the ridges, and so actually form terraces but modern practice is tending to the view that the primary object of ridges is to prevent or greatly reduce any movement of soil down the slope, and the silting-up of ridges is a secondary consideration. Excessive silting generally shows that the ridges have been too widely spaced.

When a land has been ridged, it becomes compulsory to plough on the contour, and it is in this indirect way that the most important object of ridging is achieved. When ridges on gentle slopes are originally laid out with the intention of occasionally working over them, it is still advisable to work on the contour as much as possible. By proper cultural methods, which are described later, it is possible to induce a very large proportion of the rainfall to penetrate *where it falls*, which is the ideal to be aimed at. It is impossible, however, to absorb all the water from a severe storm, and contour ridges are designed to handle the water that reaches them, hold up and absorb as much water and silt as possible while flowing along the ridge, and finally discharge the surplus.

Lands Requiring Ridging.—Formerly it was considered that only lands steeper than 1 in 40 should be ridged, but experience goes to prove that in many cases lands which are considerably flatter than that (almost level, to the eye) will

require ridging, especially if they are of large extent. This is an important factor, owing to the volume of water which collects and runs off a large land. Erosion may not be visible, but sheet washing can remove valuable plant-food unseen, and it is not good economy to put money into green-cropping, manuring and fertilizing, and allow it to be stealthily removed.

Length of Ridges.—It has been found by experience that, generally speaking, a ridge should not exceed 500 to 600 yards in length. If it is possible to discharge at both ends, a total distance of 1,000 to 1,200 yards may be covered. Very long ridges, besides being dangerous, are less efficient, as the large volume of water moves too rapidly. With the adoption of a variable gradient, which is discussed later, it is possible to increase the length slightly, but only where unavoidable.

Spacing of Ridges.—Ridges are spaced by measuring the vertical "drop", or difference of level between them. The spacing may vary from a minimum of 3 or 4 feet to a maximum of about 7 feet, and in arriving at the most suitable spacing several factors must be taken into consideration.

In the early days farmers greatly objected to closely-spaced ridges, not realizing that they need not waste land nor that the difficulty of working was more than balanced by the benefits gained. The principle of maximum penetration was also neglected. In many instances farmers asked for ridges at wide intervals, and suggested that they would have intermediate ridges later, but this has usually been neglected. In all such cases farmers are advised to have the intermediate ridges put in without delay. With the ultra-wide spacing silting is apt to be excessive, maintenance is expensive, and there is a constant danger of breaching.

The spacing of ridges should be decided by a consideration of a number of factors. On "flat" lands a smaller vertical interval should be allowed, so that the maximum distance between ridges should not normally exceed 70 yards. If too large an area is left between the ridges, the volume of water collected will cause sheet or gully erosion and rapidly silt up the ridges. On steeper lands a bigger drop may be allowed between ridges. In the past a drop of 7 ft. 6 in. has been generally adopted, but it is felt advisable to reduce this to about 6 feet for average slopes and good soil conditions. With this drop, and a land slope of 1 in 25, the distance between ridges will be 50 yards. As a general rule, the area between ridges should not exceed about 7 acres.

The correct spacing will also be affected by the degree of erosion and the way in which the land has been farmed. A land badly cut by gullies and wash-outs, deficient in humus, generally in poor heart, shallow-ploughed and with a marked plough-pan will require ridges twice as close together as one that has been correctly farmed. For this reason it is wise to protect the land as early as possible.

Impervious soils, or soils which may be sandy at the surface but have an impervious sub-soil, require ridges at closer spacing than absorptive soils, for the reason that they produce a heavy run-off.

Benefits of Contour Ridges.—The primary object achieved by contour ridges is the control of erosion, and this is obtained *directly* by the ridges themselves, and *indirectly* by the fact that, on all but the flattest land, all farming operations must be carried out *on the contour*. This is the greatest benefit of all, as it not only prevents erosion but tends to hold the water where it falls and secures more uniform absorption.

That is the second great benefit of ridges, that they encourage water conservation, which carries the crop through a drought and makes it more resistant to disease, replenishes the deep supplies underground and so strengthens the yield of wells and boreholes and keeps the vleis and streams going months after the rains have finished.

By a paradox, contour ridges also improve wet land, which usually lies at the foot of a slope, and when the upper lands have been ridged the water is prevented from reaching and lying on the flat lands below. That is to say, the water is retained where it will do most good.

In other words, the benefits of contour ridges are even more apparent in abnormally wet or dry years than in normal seasons.

After ridging the land above a pan that was formerly water-logged, the pan can be safely drained by ridges on a slightly steeper gradient than normal.

By preventing the movement of soil, contour ridges prevent fertilizer, humus and other plant-food from being washed away. Thus, although they do not actually create an increased crop yield, they prevent wastage, and ensure that *full* value is obtained from fertilizing and green-cropping, so that a programme of good farming can be undertaken in the secure knowledge that it will not be wasted. Calculations based on the experiments at "Glenara" go to prove that to replace the plant-food removed each year by erosion on unprotected lands would cost in the region of at least £2 to £3 per acre at current market prices.

Much of the plant food is present in virgin soil. It should not be wasted merely because it is free, and farmers should realize that it costs money in fertilizer and more frequent green-cropping to replace it.

When a land has not only eroded, but has been cropped regularly for a long time without fertilizing or green-cropping it is too much to expect a jump in crop yield immediately it has been ridged. The land must be properly farmed and treated for some time, and then the real benefits of contour ridges will be felt. It pays to get a good crop as soon as possible, and if the soil is badly impoverished a green crop should be planted the very first year and fertilized to make sure that it is a good one. Special loans are available to enable farmers to fertilize green-crops planted on recently protected lands. Recommended green-crops are sunnhemp, or sunflowers and velvet beans interplanted.

It is difficult enough to grow a bumper crop even in a good season. Soil conservation, which includes both protective work and good farming, should

make a good crop certain even in unfavourable seasons, when prices are best. The few farmers who regularly produced yields which are relatively high for their districts will be found to practise soil conservation in the wider meaning of the term.

FARMING OF CONTOUR-RIDGED LAND

Ploughing should always be done on the contour, except on very flat lands where it is permissible occasionally to plough across the ridges if they are made wide enough.

The extra time taken to plough a contour-ridged land is very small, except on steep slopes and acute curves, and in such cases the absence of gullies often more than compensates for the inconvenience, apart from the fact that without ridges there might be no land to plough.

On steep lands or where the ridges are narrow it is not possible to plough across the ridges, and a difficulty arises from the fact that the ridges are seldom parallel, and wedge-shaped pieces of land are left unploughed. To avoid excessive turning and trampling on the land it is best to plough these pieces separately with a single-furrow or reversible plough.

Another difficulty that arises sooner or later is that, through the ploughs always being entered in the same furrow, the finishing and opening furrows eventually become hollows and banks. When once the ridges have been sufficiently widened by ploughing against them it is advisable to change the system of striking out. Even before this time it may be as well to alter the position of the central furrow. This can be done by ploughing the land between the ridges in two strips instead of one, and altering the widths of the two strips from year to year.

If the land has been ploughed in two strips, the two finishing furrows may be closed by ploughing them at the same time, the forward trip along one and the return trip along the other, and throwing in one direction only, which almost closes them and avoids undue turning and trampling.

On shallow soil or tobacco lands it is most important to keep the depth of the soil the same throughout the strip between the ridges. The formation of a shallow patch in the centre can be overcome by variations of the methods outlined above.

A far more serious problem is the gradual conversion of ridges into level terraces by the exclusive use of reversible ploughs throwing downwards, which denude the upper part of the land and piles the soil against the ridges. It would be physically impossible to even out the soil once this had happened. An even depth of soil can be maintained by backfurrowing in alternate years with an ordinary plough, and throwing uphill as often as possible with the reversible plough. The latter has many uses in farming contour-ridged land, but should not be used exclusively thowing downhill.

Once the ridge and trough have been made adequate they should not be increased in size but only maintained by the various methods when necessary. An unduly large bank is a waste of good soil, though this is not a common fault.

No hard and fast rule can be laid down. Each farmer must use his own discretion.

Ploughing "Headlands".—The turning of ploughs in the land without lifting them produces a hollow just inside the land and a bank at the edge. The hollow is often a serious cause of erosion. It is good practice to plough the headland up and down the slope in such a way as to work the bank into the hollow and completely fill it. The only hollow left is the small closing furrow which is in the hard ground outside the land. The most useful ploughs for the purpose are single-furrow and reversible ploughs. If they do not completely fill the hollow a land-leveller will do so.

As far as possible the formation of a hollow at the headland should be avoided by continuing the straight furrow into the veld, and turning to enter the new furrow with the plough lifted right out. In preference to ploughing round the headlands, where there is not enough room to turn outside, they should be ploughed as a separate strip, throwing in opposite directions each year.

Humus and Good Ploughing.—Two of the most vital factors in erosion control are high humus content and good ploughing. Erosion proceeds far more rapidly on impoverished land which has been poorly ploughed, and such a land may require twice as many ridges as one in good heart. It also appears that land originally deep and fertile erodes very rapidly when depleted of humus, probably due to overcropping and neglect.

Conversely, however, humus and good ploughing, with careful avoidance of trampling and packing will assist rainwater to penetrate where it falls *and where it is wanted.* The function of contour ridges is to prevent surplus water causing erosion, and to give it a further chance of being absorbed. Their action in conserving water is a secondary one. Water should be conserved to the maximum extent over the *whole* of the land, and this can best be done by good farming methods, such as rotations, fertilizing, green-cropping, manuring, deep ploughing, avoidance of puddling or packing the soil, &c.

Planting Contour-Ridged Lands.—When done by machine, the planter should start along and just *below* a ridge, and succeeding rows should follow this one. The short rows will therefore end at the trough of the ridge below, so that proper drainage is obtained, and the oxen can turn where plants are least likely to grow. If the rows are made parallel to the *lower* ridge, the short rows will be made at the upper part of the land, and the concentration of water will break through the rows. The correct method is most important when shovel-tined cultivators are used.

Strip-Cropping.—Owing to the low cost of constructing permanent protection works, strip-cropping can only be recommended as an emergency measure, or in conjunction with contour ridges.

The object of strip-cropping is to check the rush of surface water, filter out the silt which it carries, and increase the absorption of water.

The run-off and erosion on a land carrying such clean cultivated crops as (*a*) maize, cotton, tobacco and sunflowers are much greater than for low-growing, running or dense crops such as (*b*) Rhodes grass, thick sown sunnhemp,

wintersome, dolichos-bifloris, rapoko, native beans, cereals, lucerne, &c. By alternating strips, on the contour, of (*b*) crops with (*a*) crops, serious erosion is checked.

VARIOUS METHODS OF STRIP-CROPPING

(1) *Strip Interplanting or "Buffer" Strips.*—After contour-ridging a badly-eroded, badly-farmed land, and to prevent excessive soil movement during the years that the land is being re-conditioned, strips of (*b*) crops can be planted at intervals of about twenty rows. At every gully a small brushwood check should be made, and semi-permanent (*b*) crops should be planted in the silt. This method will give the quickest results in smoothing a badly-gullied land.

(2) *Strip-planting the Line of a Contour-ridge* is useful when for any reason it is not possible to build the ridge at once. The strip should be 5 to 7 yards wide, and all gullies should be blocked as under (1) above.

(3) *Strip-farming* consists of wider strips of alternating (*a*) and (*b*) crops planted on the contour, roughly pegged, but is not intended for permanent protection, and should be replaced by contour-ridges as soon as possible.

(4) *Permanent system* of strip-cropping between wide-spaced contour-ridges on steep slopes can be practised by modifications of the three methods above. For instance, hay crops and tobacco could be alternated, the hay being planted on the upper half of one strip and tobacco on the lower half, and the opposite arrangement for the next strip below the contour-ridge.

(5) " *Filling* " *Strips.*—This is a useful way of evening the distance between contour-ridges. The main crop is planted just below and along a ridge, and the rows are continued half-way down the strip. A strip-crop is then planted, and if a grass, can be used as a roadway for reaping tobacco, &c. The main crop is then continued in parallel rows almost down to the next contour ridge, when the remaining area is planted to a (*b*) crop, thus avoiding short rows and holding up silt. This strip-crop can be a permanent one.

(6) *Permanent Hedges in Veld* should be planted on the contour, and may consist of good covering grasses, and rows of aloes, briar roses, Napier grass, Vi-Vi, &c. The subject is fully described in Departmental Bulletin No. 1,016, " Natural Protection from Soil Erosion ".

(7) *On New Lands.*—It is often impossible to contour-ridge a land the same year that it is cleared, and there is a common idea that no damage will be done for two or three years. The best of the soil is the first to go, however, especially if the land is cross-ploughed. The finishing furrows should be approximately on the contour, and should not be completely closed. This narrow strip should be left unploughed, and not damaged by cross-ploughing.

(8) *Timber Breaks.*—It is a good practice on tobacco farms to leave contour strips of virgin timber about 10 yards wide every 50 to 100 yards. These strips act as wind-breaks, and reduce erosion and run-off, but should be supplemented by drains in the strips.

Provided the slope is not too steep, and the land is returned to new grass after two tobacco crops, the system is satisfactory.

(9) *Establishment of Pastures in Vleis.*—To prevent erosion while the grass is establishing itself the land should be protected by low contour-ridges of the type made with a disc-plough only, and the ridges first established to paspalum, &c. The strips between ridges should then be planted to grass, and on steep or badly-eroded land this planting should be alternated with belts of sunn-hemp, as explained in Bulletin No. 1,016.

Spreading Storm-water.—Pastures can be greatly improved if surplus storm-water, such as that discharged from contour-ridges, roads or storm-drains, or gullies, can be distributed over them by systems of contour banks which encourage the water to penetrate.

Several methods can be employed. There is the straight-forward system of contour ridges, built low and broad so that mowing-machines can work over them.

A more elaborate series of ridges is required to collect and spread the water from drains or gullies. In the latter case an earth dam, preferably with a good storage capacity, should be built with a full-sized spillway at one end, and the other end of the dam should be continued in the form of a particularly large contour ridge for some distance. The discharge at this point is spread over the pasture by a series of other ridges, short and quite level so that they discharge at both ends and pass the water on to lower ridges spilling in different directions. The water is thereby spread over a large area in small volumes, and is eventually returned to the gully or vlei, where another check-dam may be built to lead the water to a further series of ridges. All ridges should be broad and low, and planted to a good binding grass so that they can overflow occasionally without damage. Existing dams can be utilized, and the system laid out accordingly. Each scheme requires a different lay-out to take advantage of local conditions, and engineering advice should be obtained before undertaking it.

Very beneficial results can be expected from a scheme of this sort which, if properly carried out, should provide not only excellent late grazing but also an improved water supply in the paddock. Moreover, the water from storm-drains, instead of being wasted and causing damage, is put to valuable use and retained on the farm. Water from road drains, led through grass to a small dam will provide water for cattle early in the season, before general run-off has taken place.

Grass Rotation.—The practice of alternating crops with pasture "leys" every few years deserves to be adopted. Instead of leaving lands to fallow, they should be planted to a pasture grass, such as Rhodes grass which would give excellent grazing and hay. Many farms are short of grazing, since what is usually left for this purpose is poor, rocky, trampled and burnt.

A land planted to grass for 3 or 4 years and then returned to crop production will have given valuable grazing and received great benefits, provided that it has been fertilized, and properly grazed or mown. The fertilizer, manure, humus and fibre in the soil when it is re-ploughed are valuable plant foods, and put the land in better heart to resist erosion. In fact, there is no reason why

the land should not be even better than it was when first cleared, since the grass-roots may have loosened the plough-pan, and it will contain a higher proportion of humus and fibre after a well-grown grass crop than was present in the original veld.

In some cases the grass can be established by broadcasting the seed and light harrowing the surface. Common Paspalum (*dilatatum*) and the native paspalum (*scorbulatum*) have been established in this way, though the process is slow. Both these grasses seed freely and can choke out less desirable grasses if mowing and grazing is regulated to this end.

The land should be contour-ridged with the object of conserving as much water as possible, so that several beneficial results are obtained from the one process.

Legal Considerations.—There is an obligation on all persons dealing with storm-water to do so in a proper manner, without detriment to other parties. This obligation rests not only on farmers but also on such bodies as Road Councils, the Roads Department, Railways, &c. The legal position at present is not well defined, but the possibility of widening the Water Act to embrace disputes over storm-water is under consideration. The Roads and Road Traffic Act contains clauses defining the reciprocal rights and obligations of roads authorities and occupiers of land in so far as drainage on to and from roads is concerned. The principle underlying all matters of this sort is that water should be returned to its nearest natural drainage channel without harmful concentration before leaving the property concerned, and free from objectionable silt.

In practice it is impossible to lay down hard and fast rules, as each case must be treated on its merits, and for this reason it is all the more important that matters of this sort should be treated in a true spirit of co-operation. To put it no higher, A may find that though in one case he has an advantage over B, in another he may be the victim of similar action by C. An attitude of "give and take" will be to the ultimate advantage of *all* concerned, and it will nearly always enable the necessary work to be done at the least possible expense.

THE PRESERVATION OF CITRUS FRUIT JUICES*

THE following memorandum has been compiled on the basis of data supplied by the following sources: The Department of Science and Industrial Research, The Imperial Institute, The Research Station, Long Ashton, and Dr. L. Lampitt, Chief Chemist of Messrs. J. Lyons and Company. Grateful acknowledgment is made of the assistance afforded in this connection.

In the United Kingdom there is an appreciable trade in the so-called Citrus Squashes and Cordials, which, it may be pointed out, are not simply natural fruit juices but juices which have undergone some form of manufacturing or preservative treatment. In the United States of America, and to a lesser extent in certain European countries, there is a considerable trade in fruit juices which are preserved in such a way as to retain unaltered the characteristics of a fresh fruit juice.

In the United States a great impetus has been given to this trade by the medical profession who have advocated the consumption of fresh fruit juice as part of a campaign for health on account of the contents of vitamins. In consequence much attention has been devoted to the preservation of citrus juices by methods which will retain in unaltered form the vitamin contents.

This campaign has as yet not found its parallel in England; it is thought that if similar propaganda was undertaken by the medical profession in this country it would greatly stimulate a trade in fresh citrus fruit juice, and might be the means of extending considerably the consumption of citrus fruit or its equivalent in juice. At present the public has not learned to differentiate between the orange and lemon squashes which are currently sold and fresh fruit juice, and it is believed that the majority of people consume these beverages in the belief that they are actually consuming fresh fruit juice.

THE EXISTING TRADE IN CITRUS SQUASHES AND CORDIALS IN GREAT BRITAIN

Orange, lemon, grapefruit and lime squashes and cordials are fairly extensively consumed in this country and are manufactured by a number of firms. The basis of these preparations is the juice of the fruit which is imported into this country from the country of origin, usually in chestnut-wood casks which are not infrequently specially lined.

Orange juices are imported from the United States, Spain, South Africa and Jamaica. Lemon juices come from Italy, Sicily and the U.S.A., and lime juices from the Gold Coast and the West Indies.

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*By H. A. Tempany, C.B.E., D.Sc., F.I.C., Assistant Agricultural Adviser to the Colonial Office, in *Bulletin of the Imperial Institute*, Vol. XXXVI., No 3, July-September, 1938.

Lime and Lemon juices containing relatively high percentages of citric acid are frequently imported without addition, but orange juice with a lower citric acid and higher sugar content is liable to undergo fermentation during transit and has accordingly to be treated with a preservative; sulphur dioxide is usually employed for the purpose and is added to the juice in the form of potassium metabisulphite. The amount added is in the region of 700 to 800 parts of sulphur dioxide per million. Orange juices imported in this way are usually of a pale yellow colour, thick with pectinous matter and smelling and tasting strongly of sulphur dioxide.

To bring the sulphur dioxide content of orange juices, as imported, within the limits prescribed by the Foods and Drugs Act they require to be diluted to about one-third their original concentration; the diluent employed is usually syrup containing 45 per cent. by weight of sugar; to increase the acidity citric acid may be added, whilst sometimes flavouring is added also. The characteristic deep orange colour of orange squashes is obtained by adding colouring matter—usually carotene is used. In the squashes the pectin remains in the juice.

In the clear cordials the pectin is allowed to settle and the clear supernatant juice is racked off, though sometimes filtration is resorted to.

PRESERVATION OF CITRUS JUICE IN A FRESH CONDITION WITHOUT THE ADDITION OF PRESERVATIVES

The preservation of citrus fruit juice in a natural condition is by no means a simple problem. Such juices, and particularly orange juices, are liable to undergo changes on storage which include not only ordinary fermentation, but also oxidation processes which result in loss of flavour and of colour. Moreover it is not possible to treat them by sterilization or even normal pasteurisation as this results in imparting to them a cooked flavour which is unpleasant and also destroys the vitamins. Changes are also liable to occur in the pectinous material; on long keeping it tends to flocculate and precipitate in an undesirable manner; while in any case it is essential that in orange juices the pectinous material should be retained as its removal also causes a certain loss of flavour.

Five methods have become evolved for the preservation of fruit juices under conditions which fulfil in a greater or less degree the above requirements. They are as follows:—

(*a*) Preservation of fresh fruit juices by simple storage at low temperature.

(*b*) Preservation of fruit juices by "flash pasteurisation" and canning of the product.

(*c*) Concentration of fruit juices by film evaporation under reduced pressure.

(*d*) Concentration of fruit juices by freezing.

(*e*) Treatment of fruit juices by the "Matzka" process.

In the following pages some details are given concerning each of these.

PRESERVATION OF ORANGE JUICE BY STORAGE AT LOW TEMPERATURES

The preservation of orange juice by freezing was first attempted on a commercial scale in Florida in 1931. Early operations were not very successful. Part of the trouble lay in the development of an " off taste " in the frozen juices. Subsequent experience has, however, made it possible to overcome these difficulties and the process is now extensively practised.

The essential features of the process are as follows :—

The juice is extracted either from the whole fruit by means of a high speed reamer or by a cup type press or a whirl type press, using peeled fruit. After extraction the juice is run through a strainer and thence to an evacuating apparatus which removes contained air. Thereafter it is transferred direct to the containers and is stored in refrigerated rooms at temperatures which range from 32° to 42°F. It has been found that flavour and appearance are considerably affected by the methods of extraction and it is necessary to avoid the inclusion of too much essential oil and also bitter principles from the skin. The de-aeration treatment is also very important as this affects the keeping qualities of the juice. If de-aeration is omitted juices are liable to darken in colour and go off in flavour as the result of oxidation.

Orange juice treated in this way can be preserved for several weeks in a fresh condition. A very large trade has sprung up in the United States of America in this type of juice during the last few years ; it is largely in the hands of cold storage companies and dairies. The juice is commonly stored and delivered in cardboard containers and it is normal in American cities for a carton of orange juice to be delivered at the doors of households with the morning milk.

PRESERVATION OF FRUIT JUICES BY FLASH PASTEURISATION AND CANNING

The flash pasteurisation method for preserving fruit juices consists essentially in raising the temperature to 185° to 190° F. and maintaining it at that for about ten seconds ; treatment in this way gives results comparable to heating to 160° F. for 30 minutes. The advantage of this method as opposed to ordinary pasteurisation is that as the juice is exposed to the high temperature for a very short period the development of the cooked flavour, which is an undesirable concomitant of heat treatment, is avoided.

As in the case of the preservation of fresh juices by cold storage the pasteurisation process must also be accompanied by de-aeration if successful results are to be obtained. It is also usual to combine with them treatment of the juice with a pectin destroying enzyme which enables the opacity of the juice to be controlled without affecting the flavour to the extent that would occur if the pectinous constituents were removed by filtration. Various enzymes of this nature are now marketed by a number of firms under different names. The enzyme is added to the juice after extraction and before de-aeration and pasteurisation, which have the effect of destroying the enzyme, and sufficient interval is allowed to enable the enzyme to perform its functions before the subsequent processes are proceeded with.

In the production of pasteurised citrus juices very careful selection of the fruit is essential and all damaged and partially decayed fruit must be rigorously excluded. The methods of extraction employed are also important, for unsuitable methods of extraction are liable to affect, as with cold stored juice, the flavour unfavourably. A method extensively employed is to halve the fruit mechanically and to hand-spindle the half sections over revolving burrs. Attempts have been made to crush the whole fruit in its natural state, but this method has been discontinued on account of the strong flavour imparted to the extract by the oil contained in the skin. This flavour is regarded as objectionable.

An outline is given below of a method of preparing the juice employed at an American factory which embodies the Stero-Vac process of flash pasteurisation which is claimed to be one of the most efficient for producing this type of product.

The fruit is first grated to remove the oil and then pressed whole, the juice being strained to remove seeds and pulp. The grater consists of two horizontal revolving discs about 4 feet in diameter, covered with a stainless steel fillet, which rotate at a speed of about 100 r.p.m. and revolve in opposite directions. The fruit is thrown by centrifugal action against the fillet, which punctures the oil cells. The fruit leaves the outside of the first revolving disc and is transferred to the second disc where the grating is continued. At the centre it drops into a continuous press consisting of two discs of stainless steel about three feet in diameter, which revolve in the same direction and come together for a short distance on one side. The whole fruit rolls from the grater into one side of this, is crushed and the juice extracted. After pressing, the crushed peel is lifted off the disc and the juice flows into a stainless steel trough which surrounds the lower disc. It then flows to a finisher which is a mechanical strainer of stainless steel. From the finisher the juice flows to the de-aerating unit which consists of a steam chest with a separating chamber and a condenser, all constructed from stainless steel. Juice flows through the pipes of the steam chest—which are surrounded with hot vapour—under a high vacuum of about 28 inches. Juice flows continuously from the extractors through the finisher and the de-aerating unit and is pumped out by a stainless steel vacuum pump to the can filler, which is so constructed that the juice may be broken to atmospheric pressure in an inert gas such as nitrogen.

For packing grape fruit juice plain tin cans are used, but with orange juice lacquered cans are employed in order to avoid flavour changes. After filling the juice in the cans, it is flash pasteurised by the Stero-Vac process. This process involves heating by steam injection through a patented valve in the end of each can and is performed on a specially designed machine. As the can is removed from the machine the disc in the valve is snapped into place as the result of the change in pressure ; it is subsequently sealed by clinching and the cans rapidly cooled. The essential features of the process are quick heating and quick cooling combined with the removal of dissolved air.

Another method of flash pasteurisation has been devised at Long Ashton, where a series of experiments have been carried out on apple juice. In this method flash pasteurisation is accomplished by causing juice to flow as a thin film

between two metal sides of a container, which are raised to the temperature of boiling water. The juice is de-aerated subsequently to this and then canned. The Long Ashton authorities have kindly undertaken to carry out tests with this apparatus on samples of citrus fruit juice from Palestine.

CONCENTRATION OF FRUIT JUICES IN VACUO

There has been a not inconsiderable development of the concentration of fruit juices in vacuo in recent years. The principle employed is that of film evaporation which has been commercially developed in a variety of industries in the Kestner type of evaporators. The advantage of the process is that as evaporation takes place from the surface of a thin film it proceeds very rapidly while the high vacuum under which it is performed permits of the employment of a relatively low temperature.

In this way, as in the flash pasteurisation process, it becomes possible to avoid the occurrence in fruit juices concentrated by means of it of the cooked flavour, which is objectionable.

In the process as applied to fruit juices it has been found necessary to make special provision for retaining certain volatile substances which affect the flavour of the finished product and which are removed during the course of evaporation. This is accomplished by the incorporation in the plant of a special device whereby these substances are trapped and condensed, thus permitting of their readdition to the finished product.

A number of plants are engaged on the commercial operation of this process in the United States and a number of brands of concentrated orange juice prepared by the process are on the market. One of the best known is called "Califorange". There is already a small import of this type of product into the United Kingdom, where it is finding increasing favour with manufacturers of orange squashes and cordials.

In operation it is understood that after extraction of the juice some of the pulp may be removed by filtration or by treatment with enzyme in order to obtain a product that is not too viscous and difficult to handle. Such concentrated juices contain about 60 to 70 per cent. total solid matter and it is stated that they can be kept without change at ordinary atmospheric temperature indefinitely. It is understood that the preparation of pure concentrated orange juice by the process is sometimes difficult by reason of the low acidity which affects the keeping properties and that a trade is in consequence springing up in mixtures of concentrated orange and lemon juices, the higher acidity of the lemon juice enhancing the keeping powers of the mixture.

It is understood that one small factory in Palestine has experimented with the concentration of fruit juice in vacuo.

THE CONCENTRATION OF FRUIT JUICES BY THE METHOD OF FREEZING

Possibly the most interesting of all the various processes for concentrating fruit juice is that of concentration by freezing. The process depends on the application of the well-known principle that when a solution is cooled below

the freezing point of water separation into two phases occurs, a solid phase consisting of pure ice crystals and a liquid phase consisting of the original solution in a more concentrated condition. Theoretically, therefore, it is possible to effect concentration to any desired degree by freezing the solution and then separating out the ice crystals. The process has seen its most important commercial development in Germany under the title of the Krause Process, from the name of its inventor, G. A. Krause, of Munich. There are six or seven examples of the plant at work in Germany and Switzerland. A freezing process has also been developed in France with special reference to the concentration of wines and grape juices. A certain amount of experimental work on the method has been performed by the Department of Scientific and Industrial Research at the Low Temperature Research Station at Cambridge and by the Daniel Sieff Research Institute in Palestine.

It is understood that the process has not so far obtained any commercial application in the United States of America, but the operations of the Krause concern are being watched very closely with a view to possible industrial development.

In its original form the Krause process consisted essentially in freezing the juice in some form of suitable vessel and then transferring the frozen mass to a centrifugal in which the concentrate was separated from the ice crystals by centrifuging. Worked in this way the process has certain obvious disadvantages ; in the first place it is discontinuous ; a further and more serious objection is that by freezing alone it is only possible to effect concentration up to a total solid content of 55 to 60 per cent. Concentrated to this extent fruit juices are incapable of being preserved unchanged at ordinary atmospheric temperatures and require to be stored under refrigerated conditions if they are not to develop undesirable characteristics, such as darkening in colour, change of flavour, and alterations in the pectinous constituents which cause them to flocculate and precipitate out very rapidly.

Samples of orange juice concentrated in this way and stored at —20° C. for over a year were seen at Cambridge and were found on dilution to have preserved their flavour very well indeed and to correspond exactly with fresh orange juice. It is obvious that the necessity for storage at low temperatures is a serious drawback, and it has more recently been stated that if higher concentrations of total solids can be obtained this drawback is removed and juices will keep unchanged at air temperatures. It is considered by Krause and others that concentrations of between 60 and 65 per cent. are reasonably safe, but the susceptibility of concentrates to change is a function of the acidity and juices of low acidity require a higher degree of concentration than do juices with higher acidity if they are to maintain their condition at air temperatures.

The acidity of citrus fruit juices, is, however, in their favour in this respect.

One of the difficulties in the way of securing higher concentrations than 50 per cent. is that at greater concentrations the concentrates become viscous and do not part readily from the ice crystals. One method of getting over

this difficulty would appear to be pretreatment of the juices with enzyme to dissolve some of the suspended pectinous material, thereby lowering the viscosity of the finished product.

It is stated that Krause has now perfected a modification of his original process whereby all these difficulties have been surmounted and fruit juices concentrated up to 80 per cent. total solids content, while the process has in addition been made continuous. Through the courtesy of Dr. Lampitt of Messrs. J. Lyons and Company, samples of raspberry and apple juice concentrates stored at air temperature were seen and it was stated that they had been concentrated up to 80 per cent. total solids content. They appeared to have retained unchanged the aroma and flavour of the original juices. A factory incorporating all the latest innovations is stated to be operating in the Rhineland, but details of the modified Krause process are at present jealously guarded. For what it is worth, I may say that it is believed that the modified Krause process incorporates the principles of pretreatment with a pectin destroying enzyme, preliminary concentration by freezing, followed by final concentration by heat under reduced pressure, but no certainty can attach to this.

It is believed by a number of authorities that ultimately the freezing method or a modification thereof will supersede all other methods of concentration of fruit juices.

It is understood that representatives of the Krause concern have been appointed in the majority of countries.

THE MATZKA PROCESS

The Matzka process is so called after its original inventor Dr. Wincenty Matzka.

The process seems to depend upon a combination of low temperature flash pasteurisation and metallic silver sterilisation, the liquid being passed in thin layers between two heated metal surfaces. The temperatures attained by the juices are, however, lower than those usually considered necessary for pasteurisation, actually temperatures of from 130–140° F. are employed, and the sterilising action is claimed to depend on the so-called oligodynamic action of the metal with which it is in contact. Moreover, the two metal surfaces are different and electrically insulated from one another so that some electrolytic action is supposed to take place. A certain amount of the metals goes into solution, and the possible effect of this on human health has been questioned.

The process has been tested experimentally by the Ontario Research Foundation and a report on these investigations has been published under the signature of Dr. A. Douglas Barbour, Head of the Biochemistry Department.

In its simplest form the apparatus consists of two concentric tubes, the inner one being of silver and the outer of stainless steel; heat can be applied to the inner surface of the inner tube and the outer surface of the outer tube while the juice under treatment flows through the space between the two tubes. Juice intended for treatment requires to be de-aerated as in ordinary

flash pasteurisation, and may be treated with an enzyme or filtered to clarify it. After treatment, the juice is filled direct into bottles with suitable arrangements for sterilising them so as to prevent after-infection.

Various juices were treated experimentally in the Ontario trials and uniformly satisfactory results were reported. Among the juices treated were orange juice and grapefruit juice, and it is claimed that the products, as well as keeping satisfactorily, compared very favourably with commercial samples of similar juices which had been prepared by the ordinary flash pasteurisation process. Commercial plants are stated to be operating the process at Tiel in Holland, at Tremestieri in Sicily, at Carcagente near Valencia in Spain, at Cheswold, Delaware, in the U.S.A., and at Whitby, Ontario, in Canada.

It is further stated that samples of Matzka processed juice have been examined by officers of The National Research Council of Canada, who were satisfied that it had a superior and more natural flavour than any other processed fruit juice sampled. It is further stated that the concern at Whitby, Ontario, which was inaugurated in November, 1937, has had difficulty in keeping up with the demand for its products.

CONCLUSION

To sum the matter up, the present trade in citrus juices in this country is mainly concerned with the orange, lemon, and grapefruit squashes and cordials which are extensively sold. These are, however, far removed from natural fruit juices, and it is believed that if a regular supply of fruit juices preserved by more modern methods became available they would rapidly replace the existing types.

There seems little doubt that the existing demand by the trade in this country is for raw juices rather than for concentrated juices. This is doubtless because the unconcentrated juices at present suit methods of manufacture. If, however, by freezing or other method of concentration the trade could obtain a concentrated juice offering technical or commercial advantage over the present raw juice they would doubtless resort to this material. That there is increasing interest in concentrated juices is shown by the fact that small quantities of juice concentrated by the vacuum process are already coming in.

There also seems reason to believe that interest in fruit juices is being fostered by the milk bars, which are appearing in increasing numbers, at most of which there is a growing sale for fruit juices, especially in the summer.

There also seems little doubt that consumption of citrus juices would receive a considerable impetus if it was as extensively advocated by the medical profession in the United Kingdom as it has been in the United States of America. The great extension of the consumption in the latter country is largely attributed to this factor.

It is not altogether clear which of the processes of preserving citrus juices described offers the greatest prospect of success, *i.e.*, (*a*) extraction of fresh fruit juice, its de-aeration and preservation by cold storage for short periods, (*b*) the preservation of fruit juice by flash pasteurisation and de-aeration followed

by subsequent canning, (*c*) concentration of juice in vacuo by a film evaporation process, (*d*) concentration by freezing on the lines of the Krause process, or (*e*) preservation by the Matzka process.

The Krause process of concentration by freezing is thought by some to offer the best prospects in the long run. On the other hand, if the Matzka process fulfils its present promise it also seems to hold out possibilities, but the objection to this process by reason of the presence in the treated juice of small quantities of silver must not be overlooked.

The Department of Scientific and Industrial Research have pointed out that there is no possibility of patenting the actual process of concentration by freezing *per se*. The only points over which patent rights can extend are the details of the apparatus employed.

In conclusion it may be pointed out that while the foregoing information applies in the first instance to the preservation of citrus fruit juices it also has a direct bearing on the preservation of juices of other kinds of fruit. In the Colonial Dependencies interest in this connection at present attaches particularly to the preservation of pineapple juice in Malaya and certain other Dependencies and to passion fruit juice in Kenya; consequently although the application of the data given lies in the first place in those Dependencies in which citrus fruit is grown, it also has an interest for a number of others.

ADDENDUM

FURTHER INFORMATION CONCERNING THE KRAUSE PROCESS

Since the foregoing was written further information concerning the Krause process has been made available in a paper by P. Bilham published in *Chemistry and Industry*, Volume 57, No. 25, pages 589-593, of June 18, 1938, and from this the following additional notes have been abstracted :—

According to Bilham the process in its present form consists in double or treble freezing in a stationary condition, transferring the ice block to a centrifugal, removing the mother liquor by whizzing, and subsequently concentrating the mother liquor by the same means.

The juice is frozen in a special vessel of such a shape and size that the moulded block of frozen material exactly fits the centrifuge employed, the general shape of the juice space is an annular ring which tapers slightly from top to bottom. The vessel is immersed in a brine tank and the brine circulates outside and inside the ring of the container thus ensuring that the temperature gradient is horizontal, which causes the ice crystals to grow along this gradient and so facilitates the separation of the concentrate.

A framework is immersed in the liquid to be concentrated, which provides a means of handling the frozen block and helps to prevent the frozen mass from disintegrating. The remainder of the plant consists of the brine tanks in which the brine is specially circulated for freezing, a second brine tank in which after a certain period of freezing the cell is allowed to "temper" (whereby

the temperature of the frozen mass becomes even throughout) and the centrifuge which is provided with a central pipe entering the bowl for the introduction of liquids to wash the ice mass. The whole plant is made of corrosion resistant alloys.

Two brine tanks are provided for freezing and one for tempering, there is one centrifuge, and auxiliary apparatus comprises refrigerating plant and thermostats with storage tanks.

In operation a cell is filled with juice and placed in the first freezing tank for an hour, it is then removed and placed in the tempering tank for an hour, which levels out the temperature throughout the mass. The cell is then plunged into warm water and immediately the content is free it is lifted on its frame, placed in the centrifuge and spun until concentrate ceases to issue from the discharge pipe. The mass is then washed with original juice and then with ice water from previously discarded ice. The washings are used again and again until the solid content has been raised nearly to the level of the first concentrate. They are then added to the bulk.

The process on the second and third concentrations is similar, save that lower temperatures are employed, while the ice from the last concentration is not washed but is added as it is to the original juice.

A cell is filled every twelve minutes and put to freeze ; during the interval cells due for centrifuging have to be handled : ice removed from the bowl at the end of washing, transfers made from freezing to tempering tanks, and filling of second and third concentration cells made. The work is stated to be capable of being carried out by four men. The plant has a capacity of 1,250 litres of original juice per hour for continuous night and day work, the latter is essential for successful operation. With wages at 1*s*. 3*d*. per hour, electricity at 1*d*. per unit, and cooling water at 3*d*. per 1,000 gallons the prime cost of concentration is stated to be 1*d*. per gallon of finished product using three stages.

It is stated that the juices produced are excellent in flavour, but to ensure their keeping it is required that the soluble solid-contents be raised to 60 to 65 per cent. by the addition of sugar. With this they will keep well for six months at a temperature of 5° C. This is not in complete accord with earlier claims reported for juices concentrated by this process. It is also stated that the removal of pectin from concentrated juice by the use of pectin destroying enzymes has been proposed, but it is not clear whether this is as yet actually incorporated in the process.

THE PRODUCTION OF ARTIFICIAL MANURE ON THE FARM*

FARM manure constitutes an important means of maintaining the organic matter of the soil. However, there are many farms upon which there is only a small amount of manure produced and on most farms the supply is inadequate for the needs of all the land. There is a real need for more farm manure. Usually on the farm there is an abundance of crop residues which might be used to better advantage if they could be converted into manure by artificial means at a cost not too great. A method of converting crop residues and agricultural waste products into farm manure by artificial means would, to a certain extent, meet this need.

A number of experiment stations have carried out experiments to determine if it is possible to convert such materials as grass, leaves, leaf mold, peat, muck, peaty muck, straw, cornstalks and other crop residues into manure. Several methods have been tried to see how practical the process might be. These experiments have shown that it is possible to convert waste materials into a good grade of manure provided proper conditions are maintained.

Micro-organisms which bring about decomposition usually are present and do not need to be supplied. However, it is necessary to add a small amount of nitrogen that the micro-organisms may work more efficiently. Certain acids are produced and the compost becomes sour or acid and the activity of the micro-organisms is greatly hindered, if not completely suspended, unless some material such as limestone is added to neutralize these acids or to sweeten the sour condition. Water is essential for many reactions brought about in the decomposition of the compost; also a great deal of heat is developed, the compost dries out and biological action is checked unless a sufficient amount of water is present. Rainfall will supply a large part of the water required but for practical purposes the rainfall needs to be supplemented by additions of water, especially during the first stages of decomposition.

A good grade of artificial manure can be made from leaf mold, grass, straw, or other plant residues, water and a reagent containing nitrogen and lime. Nitrogen may be supplied in various materials, such as cyanamid, ammonium sulfate, sodium nitrate, calcium nitrate, cotton seed meal, tankage, liquid manure, chicken manure, or even green crotolaria. A very effective and inexpensive reagent may be made from a mixture of equal parts of cyanamid and finely ground rock phosphate. If this reagent is used it will not be necessary to add lime, as the cyanamid contains enough of this constituent. If, however, ammonium sulfate is used to supply the nitrogen it will be necessary

*University of Florida Press Bulletin 517, August, 1938. By F. B. Smith, Soil Microbiologist, Florida Experiment Station.

to add limestone. The mixture generally recommended consists of 45 pounds of ammonium sulfate, 15 pounds of superphosphate and 40 pounds of limestone, used at the rate of 150 pounds per ton of litter or straw. If acid peat or muck is to be composted, perhaps larger quantities of limestone should be used, depending upon the acidity and the material.

The reagent may be mixed with grass or straw by means of a hopper. This method has proved very satisfactory, saving much time and labor, and involving little expense. The hopper is a simple device for feeding the reagent into the straw conveniently. The agitator in the hopper may be driven by a power takeoff from a tractor. The straw or other material is conveniently blown in place where it is packed down and wet thoroughly. Water may be supplied from a tank, near-by well, stream or pond. When made this way, the finished compost heap should be not more than 4 or 5 feet high and constructed in such manner as to retain a maximum amount of rainfall. Composts made in late summer should be forked over and completely reworked the following spring to mix thoroughly the dry and moist portions and so hasten decomposition. Ordinarily this compost will be thoroughly decomposed by the end of summer or early fall and may be spread on the land the same as ordinary manure.

If a mechanical mixer or hopper cannot be obtained, or if materials other than straw are to be composted, the compost may be made by hand as follows:—

Select a level place, about 10 feet square for each ton of material, and make a layer about one foot thick. If dry material is used this will require about 400 pounds. Sprinkle the material with water from a garden hose until wet and pack firmly. Then spread about 20 or 30 pounds of the reagent uniformly over the surface of the wet material. Another layer is made on this one and the process is repeated until 5 layers have been made or approximately 1 ton of dry material and 100 to 150 pounds of the reagent have been used. The materials should be spread evenly and the top left flat or with a slight depression in the centre to catch and retain as much rainfall as possible. It has been found that 200 to 400 gallons of water are required for a ton of dry material. If the materials are wet or if green materials and dry materials are mixed, as is often the case, less water is required to wet the compost in the beginning. Too much water should not be used at one time as there is danger of washing out the reagent. Compost made in this way can be put up at any time but will require about four months of warm weather for thorough decomposition, unless particular care is taken to regulate the moisture content.

When manure is available, a compost may be prepared as follows:—

Put down a layer, 4 to 6 inches deep, of the material to be composted and place a layer of the manure 2 to 3 inches deep on top. Then add water to wet the compost thoroughly, but not enough to cause leaching. The process is repeated, building up the compost heap with alternate layers of litter and manure.

Experiments with manure made in this way have shown it to be comparable to ordinary farm manure, giving about the same effects in every way and having about the same value. Two tons of manure having a moisture content, of 75 to 80 per cent. can be made from 1 ton of straw or cornstalks.

The practice of making artificial farm manure cannot be recommended for general farm use, but where conditions are favorable and the facilities are available at little cost, artificial farm manure may be produced which will be equal in value to farm manure and will serve to supplement the inadequate supply of that important fertilizing material. On the other hand, an alternative practice on the general farm has been suggested. Instead of burning weeds, grass and crop residues which decompose slowly when plowed under, an application of some nitrogen carrier, such as cyanamid, permits the decomposition of such residues and may be an important means of fixing carbon in the soil.

XIIth WORLD'S DAIRY CONGRESS, VIENNA, 1940

The XIIth World's Dairy Congress will be held in Vienna in 1940, towards the end of May and the beginning of June.

Booklets giving particulars of the arrangements are available and can be obtained on application to the Director of Agriculture, Peradeniya.

THE SOUR CREAM METHOD OF MAKING CLARIFIED BUTTER (GHEE)*

THE principle underlying all methods of butter clarification is the removal of moisture, protein, and other milk solids so as to facilitate the preservation of the butter-fat. In the older methods, part of the moisture and salts and a large proportion of the proteins were removed during the making of butter prior to clarification. In order to eliminate the work of making butter, a method was developed to make the clarified butter directly from cream and this was described in a previous article in this BULLETIN (1936, **34**, 32). I stated there that the direct boiling of untreated fresh cream was not a success because the large amount of protein curd stuck to the pan and charred. This difficulty was overcome by mixing the fresh cream with water and reseparating to reduce the protein content, and then this washed fresh cream was boiled.

This method of boiling washed cream has been in use in the Government supervised creameries for the past 18 months and very good results have been obtained. One drawback, however, to this method is the frequent shortage of clean water at outlying creameries. It has also happened that cream from a small collecting centre has started to sour before it has reached the central creamery and difficulty has then been found in reseparating the cream and water mixture. In order to reduce the creamery working hours and to overcome these difficulties experiments have been made to bring about the protein separation without it sticking to the pan and burning.

The method now adopted is to allow the fresh cream to ripen until the next day (about 20 hours) and then to boil this sour cream directly without further treatment or washing. The boiling proceeds evenly and the last traces of water boil off smoothly without the spitting usually encountered when boiling washed fresh cream. The protein separates completely and so long as the contents of the boiling pan are stirred gently in the later stages, no charring takes place.

The keeping qualities of clarified butter made from sour cream are quite as good as those of any other type, whilst the product is quite as solid and attractive as the best made in this Territory. Clarified butter made from soured cream can be quite free from any trace of rancidity provided the boiling is done completely and not stopped before the stage described in the earlier article. The acidity compares very well with that of the best quality clarified butter. In the last 20 samples analysed the free fatty acid content of clarified butter made from sour cream ranged from 0·18 to 0·34 per cent. (as oleic acid). These very low values are extremely satisfactory.

*By M. H. French, M.A., Ph.D., of the Veterinary Laboratory, Mpwapwa, Tanganyika Territory, in the *Bulletin of the Imperial Institute*, Vol. XXXVI., No. 3, July-September, 1938.

Govinna Estate,
Govinna,
23rd November, 1938.

The Editor,
The Tropical Agriculturist,
Peradeniya.

BURYING OF PLANT REFUSE IN RELATION TO CONTROL OF THE RHINOCEROS BEETLE AND LEPIDIOTA

DEAR SIR,

A coconut planter told me that on his private coconut estate near Veyangoda he had cut many pits and filled some with husks and Calcium cyanamide only, and others with husks, cyanamide, and green stuff. Later on, his superintendent reported a severe mass outbreak of rhinoceros beetle. Examination showed that the pits had become a prolific breeding ground for *Oryctes* (Rhinoceros beetle). These, however, were found in the holes with husks only and not in those to which green stuff had been added. He suggested, as an explanation, that possibly *Oryctes* would breed only in holes filled with decayed or dead plant refuse, but not in holes to which green stuff had been added. I am not qualified to state whether this is so or not, but the allied grub, *Lepidiota*, which causes so much damage to Rubber seedlings, is well known to breed freely in holes filled with green stuff and cyanamide. The point interesting to the writer was that in the above case the holes had been filled with loppings of *Tephrosia vogelii*. This plant is now well known as a fish poison and many of our most useful insecticides have been evolved from a study of plants used for this purpose. The burying of plant residues is an agricultural practice of recognized value, but so far hampered by the encouragement it gives to such pests. It seems worth investigating whether the addition of *T. vogelii* might deter invasions of these grubs.

Yours faithfully,
(Sgd.) H. W. R. BERTRAND.

MEETINGS, CONFERENCES, &c.

RUBBER RESEARCH SCHEME (CEYLON)

DRAFT MINUTES OF THE FORTY-FIFTH MEETING OF THE RUBBER RESEARCH BOARD HELD IN THE CHAMBER OF COMMERCE BUILDING, COLOMBO, AT 10 A.M. ON THURSDAY, OCTOBER 27, 1938

Present.—Mr. E. Rodrigo, C.C.S., (in the Chair); Mr. C. H. Collins, C.C.S., (Deputy Financial Secretary); Mr. I. L. Cameron; Mr. L. M. M. Dias; Mr. L. B. de Mel, J.P., U.P.M.; Mr. G. E. de Silva, M.S.C.; Mr. L. P. Gapp; Mr. F. H. Griffith, M.S.C.; Col. T. G. Jayewardene, V.D.; Mr. F. A. Obeyesekera; Mr. J. L. D. Peiris; Mr. C. A. Pereira; Mr. B. M. Selwyn; Mr. R. A. Sharrocks.

Mr. T. E. H. O'Brien, Director, and Mr. R. K. S. Murray, Botanist and Mycologist, were also present by invitation.

Apologies for absence were received from Mr. R. P. Gaddum, J.P., U.P.M., Mr. R. C. Kannangara, M.S.C., and Mr. E. W. Whitelaw.

MINUTES

(*a*) Draft minutes of the forty-fourth meeting which had been circulated to members were confimed and signed by the Chairman.

(*b*) *Matters arising from minutes*—

1. *Identification of Clones.*—The Chairman reported that the budding Mandor, whose services had been loaned by the Rubber Research Institute of Malaya arrived on September 11, 1938, accompanied by a Ceylonese Laboratory Assistant. He was now engaged in identifying clones on estates. In reply to a question the Director stated that he was endeavouring to arrange for the period of the officers' visit to be extended.

EXPERIMENTAL COMMITTEE

Recommendations made at a meeting held on October 4, 1938, were considered :—

(*a*) *Visiting Agent's Report.*—The report of an inspection of the estates by the acting Visiting Agent, Mr. D. T. Angus, was considered and adopted.

(*b*) *Oidium Leaf Disease.*—The Chairman said that the general attitude of the Board in regard to the control of oidium had been defined at the last Board meeting. Proposals for future research work had been considered by the Experimental Committee and were now before the meeting for discussion. A letter had recently been received from the Secretary of the Planters' Association of Ceylon forwarding the following resolution passsed at the Matale

Planters' Association: "That the Rubber Research Scheme be asked to undertake further research on oidium and its control". The proposals should be considered in relation to that resolution.

Mr. Murray, then read a memorandum summarizing the work already carried out by the Research Scheme on the control of oidium, and replied to various questions. After general discussion it was decided to adopt the proposals for future work, subject to the necessary estate co-operation being forthcoming. The Chairman stated that a reply would be sent to the Planters' Association outlining the work to be undertaken.

(c) *Trials of planting material on estates.*—It was agreed that arrangements should be made for test plots of one acre each of promising new clones and their illegitimate seedlings to be established on estates in different districts. The following conditions were approved for the trials :—

(1) Planting material to be supplied free by the Research Scheme.
(2) Research Officers' recommendations for manuring and other cultivation measures to be accepted by the estates concerned.
(3) Research Officers to have facilities for making observations during the development and tapping of the trees.

(d) *Tapping trials.*—Approval was given to proposals for the comparison of various tapping systems for budded trees in co-operation with estates, with a view to ascertaining the system best suited to each particular clone.

(e) *Survey of replanted area 2A.*—A vote of Rs. 175 was passed to cover the cost of a detailed survey of this area, as recommended by the Committee.

SMALL-HOLDINGS COMMITTEE

Recommendations made at a meeting held on August 27, 1938, were considered :—

(a) *Conditions of service of Rubber Instructors.*—It was agreed that the conditions should be revised on lines recommended by the Committee.

(b) *Issue of Posters.*—The general principle of issue of posters depicting the work of the Small-holdings Department was approved.

A poster was submitted for inspection and it was agreed that it would be suitable for issue in a modified form. The Director was asked to obtain alternative estimates for printing the poster in colour.

(c) *Instructional Nurseries.*—The recommendation was approved that all budding should be done with material of approved clones except in the case of plants used for practising budding and that suitable budwood should be supplied from Nivitigalakele. A decision regarding the sale of the plants was postponed.

(d) *Marketing facilities for Village Rubber.*—In the course of discussion it was made clear that the Rubber Research Board is not directly concerned with marketing problems and that their action should be confined to drawing the attention of the proper authorities to the need for the provision of improved

facilities. It was agreed that the Commissioner for the Development of Agricultural Marketing should be asked to consider the appointment of "approved dealers" when market conditions are suitable.

ACCOUNTS

Estimates of Income and Expenditure for 1939.—Draft estimates which had been circulated to members were considered. In reply to a question the Director said the estimate of income from cess collections was based on a release of 50 per cent. of next year's exportable quota (106,000 tons). He estimated that world consumption of rubber during the next restriction period would be about 1,000,000 tons per year. On that basis the Scheme would be in a satisfactory financial position during the next 5 years.

After general discussion and minor alterations the estimates were approved as follows :—

	Rs.
Income	177,719
Expenditure Revenue	195,382
Expenditure Capital	11,742

STAFF

Reported the appointment of Mr. H. B. Wijesundara as Rubber Instructor, Ruanwella, with effect from October 1, 1938.

NEW PLANTING

Reported that applications had been made to the Rubber Controller for permission to plant 20 acres of land at Nivitigalakele in 1939 and 1940.

The meeting terminated with votes of thanks to the chair, and to the Chamber of Commerce for the use of the Committee Room.

Research Laboratories,
Dartonfield,
Agalawatta.

November 18, 1938.

REVIEW

Soils and Men : Yearbook of Agriculture, 1938.—United States Department of Agriculture.

FEW Government publications can claim for them the extreme thoroughness, broad comprehensiveness and undoubted utility in the particular sphere of their operation than the United States Department of Agriculture Yearbook. The 1936 and 1937 Yearbooks were devoted almost solely to a national, and to some extent an international, survey of practical breeding and genetical research with plants and animals. The 1938 Yearbook deals with the subject of *Soils and Men*. This mighty tome of 1232 pages is a veritable encyclopaedia of the most recent knowledge of the soil and its utilization, and yet withal so absorbingly interesting and instructive that no person with any pretensions to an interest in, and love for, the land can turn its pages without succumbing to the temptation of reading some at least of them with profit to himself and to others. In agriculture all roads lead back to the soil. Few countries have so forcibly been led to realize the vital importance of soil in the national life as the United States of America, where as a result of decades of past neglect vast areas of good agricultural land have been laid waste by erosion through wind and water. A co-ordinated approach to better land use has been the outcome.

The object of this Yearbook is to present to the people of the United States of America "facts and interpretations on soils that will promote common understanding. It is an effort to see the subject as a whole—scientific aspects, practical aspects, social and economic aspects ; the needs of individuals, groups and the nation. It is also another step toward co-operation between the natural sciences and the social sciences". In this volume the soil is treated from all angles, more than 100 authors having contributed to it.

The Yearbook is divided into five parts. In Part I., The Nation and the Soil, a series of 16 articles has been contributed by different authorities each dealing with a particular aspect of the subject. The object of this section is fourfold : (1) to describe what the public purposes in soil use are or should be ; (2) to indicate the present extent and nature of soil misuse ; (3) to discuss possible social and economic causes of misuse of the soil ; and (4) to suggest remedial action.

Part II., the longest section, deals with the Farmer and the Soil in a series of 26 articles. These describe the most recent developments in soil management and practices and include chapters on tillage, implements, soil organic matter, nitrogen, phosphorus and potash, the rotation of crops, cover crops, manures and fertilizers, erosion control, dryland farming problems, irrigation, drainage and the management of forest soils.

The problems of Soil and Plant Relationships are discussed in five papers in Part III. The soil requirements of the more important crops, the effects of the major as well as the minor chemical elements in the soil on plant and animal nutrition, and the correlation between natural vegetation and soil type here receive attention.

In Part IV., The Fundamentals of Soil Science are described in a series of nine articles covering no fewer than 139 pages. To one desirous of being acquainted with the main outlines of soil science, as it is understood to-day, no better publication than this section can be recommended. The first article, Soil and Society, is a dissertation on the part played by soil in the affairs of mankind. Following it are articles on the physical nature, the water relations and the chemistry of the soil. The role of organic matter and the activities of living organisms in the soil are then discussed. Chapters on the formation of soil, soil classification and soil maps and their use conclude the section. If for nothing else but this section, the 1938 Yearbook would be noteworthy, and would merit the greatest publicity among, and the close study of, both scientific and practical agriculturists.

Part V. on The Soils of the United States is naturally of limited interest to practical farmers and planters outside the country, but to students of the soil this section has much to commend it.

The book contains a brief but forceful preface by Mr. Henry A. Wallace, Secretary of Agriculture, and a valuable summary of sections I. to IV. by the Editor of the Office of Information. The glossary of special terms should be of material assistance to non-technical readers and others not familiar with the terminology of soil science. As many as 476 references to literature are cited in an appendix. A complete index is also furnished. The book is excellently illustrated and admirably compiled and got up. Its only disadvantage from the point of view of the general reader is its bulk, but for a work of such magnitude and importance it could hardly be expected to be less voluminous.

As Mr. Wallace states in his foreword " In this book the effort is made to discover man's duty to the soil. The book must be reckoned with by all who would build a firm foundation for the future of the United States". The reviewer would add " and for those countries, such as Ceylon, where agriculture is the mainstay of the people".—A. W. R. J.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED DECEMBER 31, 1938

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1938	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Foot-and-mouth disease	152	..	..	152	..	..
	Rabies	13	1	5	..	..	8
	Piroplasmosis	7	7	2	5	..	..
	Blackquarter	17	9	17	..	..	..
Colombo Municipality	Foot-and-mouth disease	21	..	..	21	..	..
	Anthrax	4	..	4	..	..	..
	Rabies	21	1	21	..	..	..
	Piroplasmosis	3	..	..	3	.	..
Cattle Quarantine Station	Foot-and-mouth disease	1	..	..	1	..	..
	Anthrax	38	5	38	..	..	..
Central	Foot-and-mouth disease	85	..	10	75	..	..
	Anthrax	10	..	10	..	..	..
	Rabies	11	1	4	..	..	7
	Piroplasmosis	54	..	..	54	..	..
	Blackquarter	3	..	3	..	..	..
Southern	Foot-and-mouth disease	88	..	..	88	..	..
	Rabies	5	5	..	..	..	5
Northern	Foot-and-mouth disease	59	..	14	45	..	..
	Rabies	9	2	1	..	..	8
Eastern	Foot-and-mouth disease	363	..	5	358	..	..
North-Western	Foot-and-mouth disease	23	..	..	23	..	..
	Goat Pox	29	..	..	29	..	..
	Rabies	9	1	..	..	..	9
	Haemorrhagic Septicaemia	50	..	50	..	..	..
	Piroplasmosis	5	1	1	3	1	..
	Contagious mange	76	..	42	34	..	..
North Central	Foot-and-mouth disease	706	458	10	238	458	..
	Blackquarter	20	..	20	..	..	..
	Haemorrhagic Septicaemia	6	..	6	..	..	..
Uva	Foot-and-mouth disease	508	..	15	493	..	..
	Rabies	7	1	..	..	..	7
	Blackquarter	10	..	10	..	..	..
Sabaragamuwa	Foot-and-mouth disease	78	..	..	78	..	..
	Haemorrhagic Septicaemia	1	..	1	..	..	..

Department of Agriculture,
Peradeniya. January 18, 1939.

M. CRAWFORD,
Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, DECEMBER, 1938

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	86·1	+0·7	72·7	+0·5	72	90	6·4	4·63	14	— 1·01
Puttalam ..	86·6	+1·9	71·0	+0·1	74	93	7·0	3·84	14	— 2·36
Mannar ..	83·2	+0·1	74·9	+0·3	77	86	6·8	5·93	14	— 1·88
Jaffna ..	82·1	—0·3	73·2	+0·7	75	93	6·7	13·06	17	+ 3·61
Trincomalee ..	80·3	—0·6	75·7	+0·2	81	82	6·7	7·40	20	— 5·21
Batticaloa ..	81·0	—0·9	74·1	+0·8	82	90	7·2	11·08	19	— 6·07
Hambantota ..	85·1	+0·7	73·2	+0·6	74	90	6·1	6·06	16	+ 0·47
Galle ..	83·1	—0·5	73·8	+0·7	79	90	6·2	11·23	18	+ 3·06
Ratnapura ..	86·4	—1·5	72·3	+0·8	77	95	7·3	5·65	22	— 3·55
Anuradhapura ..	83·1	+0·2	69·3	—0·2	79	95	6·8	6·90	17	— 0·71
Kurunegala ..	86·3	+0·3	71·6	+1·5	72	88	7·4	5·55	18	— 1·58
Kandy ..	83·6	+0·7	67·8	+0·6	72	95	5·8	6·60	16	— 2·46
Badulla ..	76·0	—0·7	65·2	+1·0	82	95	7·2	11·24	22	— 0·16
Diyatalawa ..	72·1	+0·1	59·8	+1·7	79	89	5·5	8·85	20	+ 0·74
Hakgala ..	66·7	+0·1	54·3	+2·2	86	91	8·4	13·65	22	+ 0·29
Nuwara Eliya ..	67·4	—0·5	50·8	+2·8	78	93	8·4	9·28	18	+ 1·26

The rainfall for December was below normal over the greater part of Ceylon, the principal districts showing excess being among the hills, particularly on their eastern and southern slopes, in the Jaffna Peninsula, and in the Galle district. The greatest excesses above normal were 25·81 inches at Hendon Estate, and 18·60 inches at Lower St. Martin's Estate while excesses between 10 and 15 inches were reported from Kurundu-Oya, Madugoda, Uva, and Dooroomadella, all on the eastern slopes of the hills. The greatest deficits below normal were 11·28 inches at Kirimutti, and 10·18 inches at Vakaneri, north of Batticaloa, while there were many deficits of 5 to 10 inches along the east coast, and a few in the south-west of Ceylon, including Labugama.

The highest monthly totals reported were 63·03 inches at Hendon, 52·94 at Upper St. Martin's, and 52·31 at Lower St. Martin's, all in the Nitre Cave district. A number of totals between 30 and 40 inches were reported from several other stations on the eastern slopes of the hills. A few stations reported less than 2 inches for the month, chiefly between Colombo and the neighbourhood of Negombo.

There were 30 daily falls of 5 inches or over during the month, from 21 stations, two stations, Hendon and Upper St. Martin's, each reporting four such falls, while Lower St. Martin's reported three, and Uva Estate two. The highest daily total was 9·63 inches, at Maha Uva, on the 17th. Nearly all these heavy falls were on the eastern slopes of the hills, on the 17th, or between the 21st and the 24th, while two were reported from the southern slopes of the hills, and one from Kankesanturai, on the 25th.

For the first half of the month, weather conditions continued fairly settled over Ceylon, with monsoon rain, generally light or moderate, in the north and east and local afternoon or evening thunderstorms in the lee of the hills. About the middle of the month the tendency to rain, particularly on the windward slopes of the hills, increased. Some very heavy falls were recorded in these districts, especially on the 17th and between the 21st and 24th, between which two days winds near Ceylon were fairly strong. After the 24th, the winds fell off in strength, but rain continued widespread, and heavy in places, till the 27th. For the last few days of the month, very little rain was recorded.

Temperatures were generally above normal, particularly night temperatures. Cloud was generally above normal, but humidity, on the whole, was about the average. Barometric pressure was below normal, while the northerly gradient was steeper than usual. Wind strength was above average, and wind direction generally N.E. or N.N.E.

H. JAMESON,
Superintendent, Observatory.

CORRIGENDA.

Vol. XCII., No. 2, February, 1939.—Page 78, line 3, for " higher " read " lower " and for " lower " read " higher."

The

Tropical Agriculturist

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The

Tropical Agriculturist

February, 1939

EDITORIAL

CONFERENCE OF COLONIAL DIRECTORS OF AGRICULTURE, 1938

MANY of the improved facilities for contact between agricultural research workers throughout the Empire which now exist are traceable to the Imperial Agricultural Research Conference held in London in 1927 and there is now no occasion for the colonial agricultural officer to pursue his investigations in comparative isolation as he was obliged to do not many years ago. Among the many useful developments which have resulted from the recommendations adopted at that conference, not the least important has been the opportunity for personal discussion provided to workers on the same subjects at periodical conferences held in London. To the various specialist conferences has now been added a conference of Colonial Directors of Agriculture. The first convocation of this nature was held in 1931 and proved so successful that it was followed by a second one in 1938. The report of the second conference has recently appeared and contains much information bearing upon agricultural problems with which Ceylon is concerned. Space does not allow more than a very brief reference here to the various items considered.

The section of the report which deals with soil erosion indicates that a sound public opinion is being formed throughout the Empire in favour of soil conservation, the prevention and check of accelerated erosion and the maintenance of fertility. It is pointed out that the chief asset of the colonial peoples is the soil and that economic policy should be planned on soil fertility and productivity, but success is unlikely to be achieved unless close co-operation is established between the Administration, technical departments of Government, local Authorities and the people. The various problems of the subject are

dealt with in the report. The report emphasizes the importance of mixed farming in maintaining soil fertility and improving the nutritional standards of the people and of the essential part which animal husbandry must play in systems of mixed farming. On the subject of nutrition, the need for close co-operation between the Medical, Agricultural, Veterinary and Education Departments is stressed and emphasis is also given to the need for the greater consumption of meat and other animal products, fruit and green vegetables if a general improvement in nutrition is to be effected. The opinion is expressed that an improvement in nutritional standards will automatically follow an improvement in the economic position of the peoples concerned and, for this reason, the increased production of local supplies of suitable food should be accompanied by the production of commercial cash crops or animal products. Reference is made in the report to the important part which the settlement of suitable people upon the land can play in solving certain social problems, but it is pointed out, no system of land settlement can be expected to succeed unless it is carefully planned. Special attention should be paid to the selection of good agricultural land having access to market centres, transport facilities and a good water supply. Settled areas should receive continual and competent supervision if they are to provide a permanent alleviation of certain social difficulties. The subject of inspection of exported produce, which is of such vital concern to the trade of many Empire countries, is one which has not yet received attention in Ceylon. The report indicates that, in spite of certain difficulties, general progress in the development of training in agriculture has been made throughout the Colonial Empire, one satisfactory result of which is that Departments of Agriculture will, in future, be in a position to meet some of their staff requirements by local recruitment. A feature of the discussion on this subject which has a special application to Ceylon, where an effort is being made to wean young men from the towns to the land, is the emphasis laid on the necessity for making rural life more attractive and the real need for the improvement of living and working conditions in rural areas. Discussion on agricultural propaganda and publicity led to the conclusion that such extension activities as demonstrations and lectures at meetings of village councils, schools, and district shows accompanied, where possible, by organized visits to demonstration stations and selected farms are of great importance and that these services can be augmented by the use of films and, in some dependencies, by broadcast talks.

It is proposed to reproduce the summary and recommendations of the conference in the next issue of this journal.

INVESTIGATIONS ON THE KEEPING QUALITY AND STORAGE OF KITUL (CARYOTA URENS) JAGGERY AND TREACLE

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TOWARDS the end of 1937, in pursuance of a resolution of the Nuwara Eliya District Agricultural Association that the question of the improvement of kitul (*Caryota urens*) jaggery and treacle be investigated by Government, field and laboratory trials were started to determine (*a*) the factors that govern the keeping quality of jaggery, (*b*) the modifications necessary in the present methods of toddy collection and jaggery manufacture to ensure a product of good storage capacity, (*c*) how jaggery is best packed for local and export purposes. Most of the kitul jaggery on the market was, until recently, packed in dried plantain leaves. While this method proved satisfactory when the product was stored by the fireplace as is commonly done in Ceylon, it was unsuitable for storage under normal air conditions. Improvements have recently been effected in packing methods. The jaggery is wrapped in oiled paper and packed in thin cardboard cartons, which in turn are enclosed in cellophane paper. Despite these improved packing methods, which cost the producer about 5 cents per packet of jaggery, serious losses have been incurred by producers because of the poor keeping quality of the product under storage conditions in retail stores. The jaggery after a period of about a fortnight begins to deliquesce. Hence the need for these investigations.

Before detailing the nature of the investigations undertaken and the results obtained, it would be advisable to describe briefly the present methods of kitul jaggery manufacture in the Central Province. The sweet toddy is collected either in clean pots, to which the leaf of *Cyminosma pedunculata*

(*S. ankenda*) or the bark of *Vateria acuminata* (*S. hal*) is added with the alleged object of preventing fermentation, or in smoked pots or in some cases in pots smeared with a light coating of lime. Frequently only toddy collected in the early morning is used for jaggery manufacture, the evening toddy being mainly used for preparing treacle. The toddy is strained into open clay or copper pots and boiled over a slow wood fire till the volume is reduced to about half. The juice is continually stirred with a wooden spoon and the froth periodically removed. In some places the syrup is allowed to cool, strained again into a smaller open pot and the boiling resumed with continuous stirring till the treacle begins to grain over the spoon. Generally, however, boiling is not interrupted, and is continuous till graining occurs. The contents are then allowed to cool for a few minutes, stirred well, and poured into moulds to set. Coconut shells are mostly used, but special wooden moulds 4 in. by $2\frac{1}{2}$ in. by 1 in. are employed if the product is for sale in retail stores. A gallon of toddy gives, on the average, $1\frac{1}{4}$ lb. of jaggery. The jaggery, when packed in cartons, is sold at 40 cents, otherwise at 15 to 20 cents per lb.

PLAN OF INVESTIGATION

The plan of the investigation was as follows. As it was obvious from a preliminary study of the subject, that the quality of the toddy was of fundamental importance in the preparation of jaggery of good keeping quality, different samples—morning and evening toddy, toddy collected in clean pots, with and without *ankenda* leaf and in limed pots—were analysed after ascertaining by preliminary tests the most suitable preservative for unlimed toddy. Mercuric chloride and formalin were the preservatives tested, the quantites of each used being, respectively, 0·15 gm. and 1·5 c.c. per 300 c.c. of juice. In view of the difficulties encountered in the analysis of toddy treated with formalin, mercuric chloride was eventually adopted as the standard preservative. Through its use, comparison of the relative rates of fermentation of differently treated samples of toddy was made possible. The next stage of the investigation was the preparation of jaggery from quantities of toddy subjected to the varying treatments. The jaggery was prepared by expert jaggery makers at Nugawela Experiment Station and at the village of Dorenagama. The jaggery samples were then examined analytically, and their storage properties studied subsequently. Storage tests were carried out with jaggery (*a*) under exposed conditions, (*b*) packed in cartons, (*c*) packed in air-tight and vacuumized tins and (*d*) in ordinary air-tight and vacuumized bottles. Tests (*c*) and (*d*) were designed with an export trade in view. Finally, the

effect of high pressures on jaggery suitably treated, was investigated in relation to the flavour, composition and keeping quality of the residual product. Simultaneously with these investigations, the changes occurring when well-limed sweet kitul toddy was retained for varying periods of time were studied at the request of the Excise Commissioner.

Methods for preserving kitul treacle were also investigated. The results of these investigations are presented in a series of five tables which will be referred to in the course of this paper. Much of the detailed data has been omitted, only such being included as afford confirmation of statements made. The same analytical methods as those described in a previous paper were followed (1).

RESULTS AND DISCUSSION

Table I below shows the analyses of toddy samples subjected to varying treatments. Where preservatives were used, they were added to the toddy immediately the pots were brought down from the trees. The analyses were made at a minimum of four hours from the time of removal from the trees:—

TABLE I

Kitul Toddy Analyses

		Brix.	Reducing Sugars gm. per 100 c.c.	Sucrose gm. per 100 c.c.	Remarks.
1.	Morning sample, preserved with formalin	13·2	0·22	12·61	—
2.	Do. mercuric chloride	13·2	0·19	12·83	-
3.	Evening sample, preserved with formalin	13·4	1·41	10·87	–
4.	Do. mercuric chloride	13·4	1·14	11·50	—
5.	Untreated	13·0	0·51	12·58	Opaque and good deal of sediment
6.	No. 5, preserved with mercuric chloride	13·0	0·36	12·99	Fairly clear and much less sediment
7.	Treated with *ankenda* leaf	13·2	0·91	11·76	Fairly clear and practically no sediment
8.	No. 7, preserved with mercuric chloride	13·2	0·67	11·62	Clear and practically no sediment
9.	Untreated	12·2	3·10	10·35	Jaggery does not set
10.	No. 9, preserved with mercuric chloride	12·2	2·44	11·92	do.
11.	Treated with *ankenda* leaf	13·2	2·79	12·03	do.
12.	No. 11, preserved with mercuric chloride	13·2	1·73	12·82	do.
13.	Treated with lime	14·4	2·10	13·72	Not sufficiently limed poor quality jaggery
14.	Untreated	14·2	1·02	13·85	—
15.	Treated with lime	13·3	Nil	12·9	Adequately limed

The following observations may be made :—

(1) Toddy collected in the morning has appreciably lower reducing sugar contents than that collected in the evening and is therefore superior for purposes of jaggery manufacture. Reducing sugars tend to render the jaggery deliquescent on keeping.

(2) Both mercuric chloride and formalin are good preservative agents, but toddy preserved with the latter shows a higher reducing sugar content because of its own reducing power on Fehling's solution.

(3) The longer untreated toddy is retained before boiling, the greater is the degree of fermentation and the poorer the keeping quality of the jaggery made from it. Toddy fermented or inverted beyond a certain degree is suited only for treacle manufacture. Jaggery of best storage capacity is made from fresh unfermented juice.

(4) *Ankenda* (S) leaf clarifies the toddy and improves the colour of the resulting jaggery. A comparison of the reducing sugar/total sugar ratios of samples 7 and 8, and 11 and 12, respectively, will indicate that the leaf does not prevent inversion. Browning and Symons found that *ankenda* leaf and *hal* bark do not prevent the fermentation of coconut toddy (2).

(5) The adequate liming of the pots with slaked lime effectively prevents inversion and fermentation, at any rate for some days. When the lime used is insufficient in quantity and not sufficiently slaked, inversion and later fermentation take place. Lime being strongly alkaline destroys both the living organisms responsible for fermentation and the enzyme invertase which causes inversion. The analyses of samples of jaggery prepared from limed toddy, shown in Table II, and previous analyses of such toddy (1) afford confirmation of the efficacy of lime in preventing inversion and fermentation of toddy. Smoking the pots after cleaning is another method of preventing the fermentation of toddy, but it is not as efficacious nor as reliable as liming.

TABLE II

"Limed" Toddy Analyses

Date of Analysis		Reducing Sugars gm. per 100 c. c.	Sucrose gm. per 100 c. c.	Acidity as Acetic Acid per cent.	Alcohol per cent. (by weight)
10.5.38		Nil	12·9	Nil	Nil
16.5.38	A.	Traces	7·6	0·33	0·95
	B.	Traces	10·8	0·15	0·16
23.5.38		Traces	0·7	1·11	1·54

In Table II above are shown the results of analysis of four separate samples obtained from a bulked sample of adequately-limed sweet toddy and retained for periods of 8 hours, 6 days and 13 days, respectively, from the time of removal from the tree. It will be noted that the 8-hour old sample was totally unfermented, the reducing sugar content being nil. The 6-day old samples, which had developed a peculiar gummy froth and a sweetish smell of alcohol tinged with acetic acid, had small percentages of alcohol and acetic acid and lower percentages of sucrose than the original toddy. Sample B was much less fermented than sample A. By the 13th day the sucrose content had fallen to less than 1 per cent. but, while the alcohol content was only about 1·5 per cent., the acetic acid content had risen to well over 1 per cent. In general it may be stated that the effect of adequate liming is to inhibit alcoholic fermentation in toddy for about 5 or 6 days, after which acetic fermentation occurs simultaneously with inhibited alcoholic fermentation. These findings are similar to those of Annett (3) and others in India with date palm toddy.

TABLE III

	Nature of Sample.	Analyses of Jaggery: Moisture Per. Cent	Reducing Sugars Per Cent.	Sucrose Per Cent.	Ash Per Cent.	Observations on keeping Quality
1.	From morning toddy, untreated	7·72	0·76	82·00	1·61	Good for one month in open
2.	From evening toddy, untreated	8·72	3·19	76·60	1·78	Inferior to 1
3.	From untreated toddy	7·52	8·58	67·78	1·29	Running after two days
4.	Do.	5·97	14·17	65·00	1·31	Very soft after five days
5.	Do. + alum	7·63	7·02	70·64	1·80	Slightly soft after five days; jaggery light-coloured
6.	From limed toddy	6·64	2·24	75·02	1·27	Hard for over six weeks; liming deficient; toddy slightly acid in reaction (pH 6·3)
7.	Do. + alum	8·02	5·17	70·62	2·80	Fairly hard for over a month
8.	Do.	4·83	Trace	87·05	1·76	Samples all kept well for about two and a half months though exposed. Toddy of high degree of alkalinity (pH 9·8) due to thorough liming
9.	Do. + citric acid	7·65	1·26	83·48	1·72	
10.	Do. + tartaric acid	7·39	1·75	82·75	1·77	
11.	Do. + alum	7·00	0·93	83·60	2·53	
12.	Do. without decanting	8·34	2·74	78·04	2·77	

Table III furnishes the analytical data of jaggery prepared from toddy subjected to different treatments and relevant observations on the keeping quality of the product.

The following points call for comment :—

(1) Jaggery prepared from morning toddy has a much higher reducing sugar and a lower sucrose content than that from evening toddy. The keeping quality of the former is therefore much superior to that of the latter.

(2) The colour of the jaggery from untreated toddy is dependent on the degree, period and continuity or otherwise of boiling. A dark colour may be due to prolonged, discontinuous or over heating.

(3) Jaggery prepared from unlimed toddy containing high proportions of reducing sugar keeps very poorly. It runs after a few days' storage.

(4) The addition of alum to unlimed toddy before boiling does not improve the keeping quality of the jaggery very appreciably but affects its colour, making it lighter.

(5) Jaggery prepared from insufficiently limed toddy is generally of superior keeping quality to that from untreated toddy but inferior to jaggery from toddy collected in well-limed pots which, in our experiments, has kept in good condition for over two months even though exposed. The flavour of limed jaggery is, however, somewhat impaired unless the excess lime is removed by deliming agents or other means. Alum, acetic acid, tartaric acid, lime juice and tamarind juice have been used for this purpose on the lines suggested by Norris and Visvanath *et al.* (3, 4, 5) for other palm saps. The deliming agents, other than alum, are added in solution in small quantities at a time till the toddy, which at first is alkaline in reaction, becomes neutral. On subsequent boiling a precipitate of the calcium salt settles and is removed by decantation. In the case of alum the limed toddy should remain alkaline even after the addition of the required amount of the material or sedimentation will be slow. Boiling is commenced only after the sediment has been decanted off. Alum has two disadvantages : (1) the loss of toddy following its use is fairly high ; (2) the resulting jaggery contains a small percentage of alumina which will, however, be low if the proper quantity is used. The much lighter colour and superior keeping quality of jaggery, so treated, are advantages in favour of alum as a deliming agent. All these deliming agents have certain disadvantages in common : (1) they cannot be used

recklessly ; (2) the quantities required would vary with different samples of limed toddy ; (3) the reaction of the treated toddy has to be tested in every case. Carbon dioxide can also be used as a deliming agent but the difficulty of obtaining a regular and cheap supply of the gas militates against its use by the villager. Experiments carried out by the writers have, however, indicated that the use of deliming agents is not essential for the preparation of jaggery of good keeping quality from limed kitul toddy. If such toddy is used, it should be subjected to a thorough preliminary boiling and then allowed to cool, when a sediment of carbonate of lime will settle at the bottom of the pot. On decanting the clear liquid and boiling it to the required stage, jaggery of good flavour and keeping quality is obtained.

TABLE IV

Ash Analyses of Jaggery.

	Nature of Sample	Ash Per Cent.	Lime Per Cent.	Chlorine Per Cent.
1.	Kitul, untreated	1·60	0·179	0·284
2.	Kitul, limed	1·61	0·180	0·251
3.	Kitul, limed + citric acid	1·72	0·178	—
4.	Do. + tartaric acid	1·77	0·246	—
5.	Do. + alum	2·53	0·421	—
6.	Palmyrah	3·79	1·21	0·441
7.	Coconut	1·16	—	0·261

An examination of Table IV, in which the lime and chlorine data of samples of kitul jaggery prepared from differently treated toddies are shown, will indicate that jaggery prepared from limed toddy in the manner prescribed contains no higher percentages of lime and chlorine than jaggery from unlimed toddy. The former does, in fact, contain less chlorine than jaggery prepared from untreated toddy.

Table IV also gives the lime and chlorine contents of palmyrah and coconut jaggery. The former has very appreciably higher lime and higher chlorine contents than kitul jaggery prepared by any of the methods referred to in this paper.

It would be relevant to consider here the subject of the boiling and setting temperatures of kitul jaggery. A number of observations made in the course of preparation of several samples of kitul jaggery confirm that the juice begins to boil at a temperature of about 210°F. and that the temperature of the thick syrup just before it " sets " is 240°F.

PRESSED JAGGERY

A recent paper by Hinchy (6) on a method of refining palmyrah jaggery led to the conducting of experiments to determine whether jaggery which had been subjected to pressure for a certain period would be of superior keeping quality to the original product. The jaggery was pounded and kneaded to an uniform consistency, packed in a drill bag and then pressed in a laboratory hydraulic press at a pressure of about 5 tons per square inch for 15–16 hours. The results of analysis of the original material, of the pressed jaggery and of the runnings are presented in Table V.

TABLE V

	Original Jaggery Per Cent.	Pressed Jaggery Per Cent.	Runnings Per Cent.
Moisture	10·13	3·83	12·49
Reducing sugars	1·19	0·47	4·09
Sucrose	81·90	91·60	29·00
Percentage jaggery after pressing		76·0	
Percentage runnings		24·0	

It will be observed that the pressed jaggery, the outturn of which is about 75 per cent. of the original, contains a considerably higher percentage of sucrose, a much lower percentage of moisture and an appreciably lower percentage of reducing sugars than the original material. The runnings, on the other hand, contain a much higher percentage of reducing sugars and a much lower percentage of sucrose.

The percentage of insoluble sugars, *e.g.*, gums, and pentosans, and other organic constituents in the runnings, is very high. The fact that the pressed jaggery has kept in excellent condition for 2½ months indicates that these insoluble and non-sugars, together with the reducing sugars, are largely responsible for jaggery becoming deliquescent in storage under normal air conditions. These substances, apparently, are also responsible for the flavour of jaggery, as pressed jaggery, unlike the original product, has no characteristic flavour.

Pressed jaggery will, therefore, be of little commercial value as jaggery, despite its good keeping quality. But it is distinctly superior to ordinary jaggery as a raw material for sugar refining.

THE PRESERVATION OF JAGGERY AND TREACLE

In order to study the question of jaggery preservation for export purposes, trials were made with canning and bottling of a good quality product (*a*) in ordinary air-tight containers and (*b*) in vacuumized containers. The jaggery was moulded to the shape and size of the tins so that but little space was left in the tin on seaming the lids. Twenty-four tins and eight bottles of

jaggery were so experimented with. The general conclusion drawn from these trials is that, for export purposes, jaggery is best packed in ordinary sealed tins which should not, however, be vacuumized. Vacuumization, especially with jaggery containing a high proportion of reducing sugars, causes deliquescence by drawing to the surface the moisture from within. Well-prepared jaggery, packed in suitably sized sealed tins, has kept in perfect condition for over $3\frac{1}{2}$ months.

For local sale purposes, provided the jaggery has been prepared from limed toddy in the manner detailed already, the present method of packing in cardboard cartons wrapped in cellophane should be sufficient to keep the product in good condition for about two months.

Trials were also conducted to determine how treacle could be preserved in good condition by (*a*) chemical, and (*b*) sterilization methods. It was found that the preservative agents, potassium or sodium metabisulphite, are effective only if added to the treacle in fairly large quantities. Their use for this purpose is, therefore, not advised. Treacle is best preserved by pasteurization. The method is as follows :—

The bottle of treacle, with the cork well fitted into and tied to its mouth by twine, is immersed in a vessel of cold water. The water is gradually heated to a temperature of 180°F.—185°F. and retained at that temperature for half-an-hour. The bottle is then removed from the water, wiped dry and allowed to cool. On cooling, the twine is untied and the cork cut flush with the mouth of the bottle which is then waxed and capsuled. The cork should be boiled in water and the bottle thoroughly washed and dried before use.

SUMMARY

The investigations started at the end of 1937 to determine the factors that govern the keeping quality of kitul jaggery and the modifications necessary in the present methods of collecting toddy or of jaggery manufacture to ensure a product of good storage capacity, were completed. The following conclusions have been drawn :—

(1) Morning toddy is superior to evening toddy for jaggery manufacture.

(2) Fresh unfermented toddy gives jaggery of the best keeping quality. The longer the toddy is kept before boiling, the greater is the degree of inversion and fermentation and the poorer the storage capacity of the jaggery. The toddy fermented beyond a certain degree is only suitable for treacle manufacture.

(3) *Ankenda* leaf does not prevent inversion but clears the juice.

(4) By adequately liming the pots, the fermentation of toddy is prevented and jaggery prepared from such toddy is of good keeping quality. Insufficiently limed toddy gives jaggery which keeps poorly.

(5) The dark colour of jaggery from unlimed toddy is due to prolonged, discontinuous or over heating. By adding alum to limed toddy, a light coloured jaggery is obtained.

(6) Deliming agents are not essential, provided the sediment is removed from the limed toddy after a good preliminary boiling. Of the deliming agents, alum gives best results but has certain disadvantages.

(7) Kitul toddy collected in well-limed pots keeps perfectly well for a period of at least 8 hours. Alcoholic, acetic and other fermentaions occur when the toddy is retained for a longer period.

(8) The boiling temperature of jaggery is 240°F.

(9) Pressed jaggery is of very good keeping quality but lacks flavour.

(10) Jaggery for export is best packed in ordinary air-tight tins. Good quality jaggery so treated has kept in good condition for over 3 months. Such jaggery, if packed in the manner now being popularized for sale in local stores, should keep well for about 2 months.

(11) Treacle is best preserved by sterilization methods.

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FIG. 1—THE ROOT-SYSTEM OF *Tephrosia*.

GREEN MANURES FOR PADDY IN THE DRY ZONE OF CEYLON

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THE incorporation of green manures in the soils of irrigated paddy fields of the dry zone should be regarded as an essential operation in the cultural practices of the crop, for the purpose of supplying nitrogen and organic matter to the soils. On a number of fields situated under village tanks, paddy cannot often be grown for two successive seasons in the year owing to the insufficient supply of water available for irrigation from these tanks. Many of the fields thus remain uncultivated for one or more seasons. During this period, however, several leguminous plants, the chief of which are *Cassia tora* Linn. (S. *tora, peti-tora* T. *takarai, vadda-takarai*) and *Tephrosia purpurea* Pers. (S. *pila* T. *kavilai, kolinchi*), may be found growing on these fields as weeds. *Cassia* often forms a thick cover soon after heavy rains, but these plants are not long-lived. They shed their leaves and seed early so that with fresh rains, a dense growth of *Cassia* seedlings may again appear. *Tephrosia* is slower growing and does not usually form such an even stand as *Cassia*, but it is longer-lived and except during periods of severe drought it does not shed its leaves. When the rains are sufficiently heavy and the tanks have filled again, these green manures are turned under the soil with the preparatory tillage operations that are carried out for paddy and this non-deliberate method of green manuring the soil for the paddy crop largely contributes to the better yields obtained in the dry zone than when paddy is grown continuously on the same land.

Although *Cassia* does not possess root nodules, the incorporation of a large quantity of fresh, succulent green material into the soils leads considerably to an increase in the organic matter of these soils. In the case of legumes like *Tephrosia*, the root system is very deep and extensive (Fig. 1). The nodules on the roots containing the nitrogen-fixing bacterium are numerous and the type of nodulation is efficient according to Fernando (1).

Although more definite methods of green manuring than that mentioned above are in progress in the dry zone, they are not sufficiently widespread yet and it is necessary, therefore,

to draw the attention of paddy cultivators to the importance of more efficient methods of green manuring for improving crop yields.

There are, generally, two ways of green manuring paddy soils, *viz.* :—

1. Collecting and transporting green leaves from outside, whether leguminous or not, and applying them at the time of flooding the fields prior to puddling for the next paddy crop.
2. Growing the green manure, which should be a legume *in situ*, and ploughing it in at the time of the first tillage operation for the next paddy crop.

The first method is more generally practised but it is not so satisfactory as the second. In extensive paddy tracts, there may be great difficulty in obtaining a sufficient supply of green material from outside. Furthermore, it is only the aboveground portions of the plants which can be utilized and, in the case of leguminous plants, the nitrogen fixed by the bacteria in the root nodules of such plants cannot be supplied to the paddy crop, owing to the difficulty of uprooting the complete plants from outside and turning them into the soil of the paddy field. The first method also entails greater expense in cutting the green material from outside and in transporting it to the paddy field.

In the second method, the green manure is usually grown on the land when there is no paddy crop on it. Where, as is generally the case under major irrigation schemes in the dry zone, two early maturing paddy crops (4 months for *maha* and 3 months for *yala*) are taken in succession during the year, the intervals between the harvesting of one crop and the sowing of the next are barely sufficient for raising a green manure. The longer interval between the two crops occurs after the harvest of the *yala* crop in August and the commencement of tillage operations for the *maha* crop, towards the end of September or early October, but cultivators are generally reluctant to devote any time to growing a green manure during this period as they are occupied with the threshing operations of their last crop before the advent of the heavy north-east monsoon rains. If, however, a single late-maturing crop is substituted for these two early-maturing crops, and it is annually cultivated, then the growing of a green manure crop in the alternate season in the year can be satisfactorily undertaken. Experimental work is necessary in order to ascertain whether the substitution of a single late-maturing crop alternated with a green manure each year would result in more economic returns than a succession of early-maturing crops grown twice a year on the land.

With the biennial cropping of paddy, the possibility of growing a green manure in association with paddy should be explored. Nicol (3) has drawn attention to the advantages of an association between a cereal and a legume and quotes several instances in primitive forms of agriculture where the mixed cropping of legumes and non-legumes on arable lands is quite common. No instances have, so far, been recorded of associated growth in paddy fields, where a legume is one of the components providing nitrogen for the non-legume, although conclusive evidence has recently been put forward by Fritsch and De (2) of the rôle of certain algae, particularly the blue-green algae, in the fixation of nitrogen in the soils of paddy fields under water-logged conditions.

There is a possibility that some leguminous plants may be found capable of growing with paddy under conditions of periodic inundation which prevail in the fields of the dry zone and that either the immediate or the subsequent paddy crop may benefit by the association. If the legume is unable to develop during the early stages in the growth of the paddy crop, on account of excessive moisture in the soil but would germinate in the later stages when the water is drained off the fields, it could be left standing when the paddy is reaped so that soon afterwards it may flower and set seed. When preparatory tillage commences for the next crop, this green manure can be turned under and the nodules developed by its roots would decay and the nitrogen fixed by the nodule bacteria would be available to this crop. It is possible, however, that a legume may be found adapted to the conditions in paddy fields during the early stages of the growth of the paddy as, in the case of the latter crop, their roots are not of the true aquatic type but they are able to thrive because the algae in these fields are able to liberate oxygen which is utilized by the roots of the paddy plants. In such cases, the legume may be able to benefit the immediate crop. If, therefore, the seed could be collected without difficulty it could be sown in such proportion to that of the cereal as to prevent its growth interfering with that of the paddy. If, however, the legume seed is shed as the pods dehisce and remains dormant in the soil, germinating either with the paddy or at some later stage, the expenditure of collecting the seed of the legume and sowing it would be saved.

In the case of the legume to be grown during the alternate season, when no paddy is cultivated, a longer-aged species may be selected but it should seed before tillage operations commence for the next paddy crop, as otherwise the cost of obtaining seed from elsewhere and sowing it in the alternate season would have to be met as an additional item. It is, of course, to be realized that a green manure which is turned into the soil

before flowering has a greater nitrogenous value than when it has been allowed to seed but, where the collection of seed from outside becomes costly, it is preferable to turn in the green manure grown *in situ* after seed production has taken place. A still further advantage would be secured if the green manure not only shed its seed before the cultural operations for the next paddy crop commenced, but also exhibited delayed germination of the seed, so that it remained dormant while the next paddy crop was on the land, germinating soon after the paddy crop was harvested. This would result in a considerable saving of expenditure both in the collection of the seed and in the resowing of the green manure each year after the paddy crop is harvested.

With these objects in view, observations were carried out with a number of leguminous green manures sown under different conditions. The green manure seed was sown (*a*) mixed with germinated paddy at the time of sowing the paddy, (*b*) prior to the ploughing of the field in preparation for sowing paddy, (*c*) before the harvest of the paddy, and (*d*) after the harvest of the paddy. Brief notes on the crops which proved to be most promising are given below, but much further work remains to be done in order to select varieties which will give the best results in increasing yields of paddy under different systems of cultivation.

1. *Phaseolus lathyroides*. This plant grows wild on certain paddy fields in the dry zone, both in the standing crop when the fields have been drained and after the harvest. It is a small, erect, semi-shrubby plant.

This species is capable of growing in association with paddy, the seeds germinating on the third or fourth day after sowing. When, however, water is let into the fields, many of the seedlings which are not on high ground or on soils where the water is not retained on the surface for long will die. The surviving plants will be as tall as the paddy and they set seed about 3–4 months after sowing. Owing to the small size of the pods collection is difficult, but the pods dehisce readily when mature and the shed seeds germinate without any period of dormancy. The pods of this plant are subject to an attack by the common Dadap moth (*Anoplocnemis phasiana*).

2. *Sesbania speciosa*. Seed of this species was sent for trial by Mr. H. C. Sampson, Economic Botanist, Kew. He collected it from abandoned paddy fields on the Tana river delta in Kenya, stating that the plants on these fields appeared to develop from self-sown seed. Owing to the presence of a hard seed coat, the seed exhibits delayed germination unless

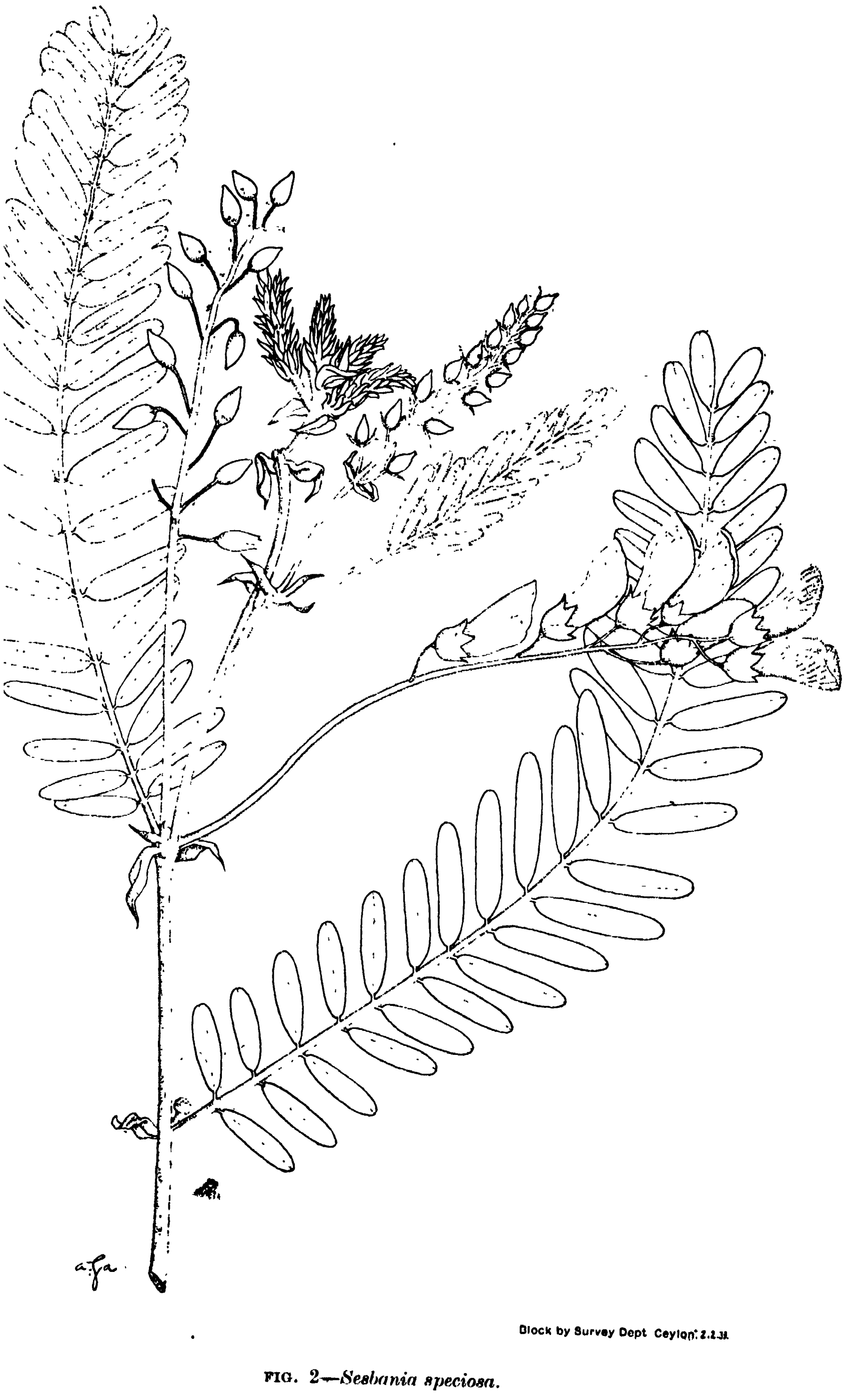

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FIG. 2—*Sesbania speciosa.*

lightly pounded with sand. The plant grows to a height of 6–8 feet and has conspicuous yellow flowers borne on terminal spikes, with the stems free from spines (Fig. 2).

When sown mixed with paddy it can germinate like *Phaseolus* on the third or fourth day, although the percentage germination is poor, and many seedlings die when the fields are flooded. Those that survive grow slowly but when the paddy is harvested they grow more rapidly. Seed which is not pounded is capable of germinating after the paddy crop is harvested but the plants that develop are few in number.

3. *Crotalaria juncea* L. (sunnhemp). This plant has been grown for many years in the north of Ceylon, chiefly for the extraction of fibre and also as a green manure and fodder crop (4). It does not germinate under water-logged conditions when paddy is growing, but comes up well when sown after the paddy is harvested and the fields are ploughed. The seed rate is very high, about 112 lb. per acre being sown in the northern part of the Island for green manuring purposes, but in an experiment carried out on paddy lands, 60 lb. per acre was found to be the optimum as against 40 and 80 lb. per acre, for the production of green material (6). Sunnhemp takes about 4½ months to produce seed and it is necessary to collect and resow the seed each season which is one of the objections to the use of this plant.

4. *Tephrosia purpurea* Pers. and *T. villosa* Pers. (S. *pila* T. *kavilai* or *kolinchi*). The first-named species is the most popular green manure in the dry zone and differs from *T. villosa,* which is rare, by its smooth or slightly pilose linear pods, the latter having stout, densely-hairy pods (Fig. 3). The flowers of *T. purpurea* are somewhat smaller and have a magenta hue while there are two varieties of *T. villosa,* one with amparo purple (Ridgeway—Colour Standards) and the other white flowers. Both are low shrubs of perennial habit with wide-spreading branches.

The two species possess hard seed coats and thus exhibit delayed germination but they do not grow in the standing crop of paddy even after lightly pounding the seeds with sand. They appear soon after the paddy crop is harvested when the fields are well drained Even if a second crop of paddy follows the first, *Tephrosia* appears after the harvest of the second paddy crop. When sown after the harvest of paddy, *Tephrosia* germinates in about a week's time but its growth is slow in comparison with *Phaseolus* and sunnhemp. The plants may flower in two months' time and seed in 3¾ months. *T. villosa* is considered to be superior to *T. purpurea* on account of its greater vegetative growth and more profuse production of pods (5).

SUMMARY

Observations carried out on a few leguminous plants suitable for growing as a green manure in paddy fields of the dry zone indicate that where a quick-growing green manure is required in the alternate season when no paddy is cultivated, sunnhemp is the most suitable, but seed has to be sown and collected again for resowing the following year. *Tephrosia purpurea*, or preferably *T. villosa*, is, on the other hand, slower growing, but when once established need not be resown as it is capable of shedding its seed which remains dormant until the next paddy crop is harvested. It is more drought-resistant than sunnhemp. *Phaseolus lathyroides* is capable of growing in association with paddy and at about the same rate, provided the fields are not kept inundated for too long periods at a time. *Sesbania speciosa* can also germinate with paddy but it does not develop at the same rate as the paddy plant though, after harvest of the paddy, it grows more rapidly. It does not, however, form an even stand, but the seeds when shed can remain dormant in the soil for several months.

Experimental work is now desired to compare the yields of paddy when a single late-maturing crop is grown in one year followed by a leguminous green manure such as sunnhemp, or *Tephrosia villosa*, in the alternate season, as against two early maturing crops, in which a leguminous green manure is grown in association with the paddy at each season.

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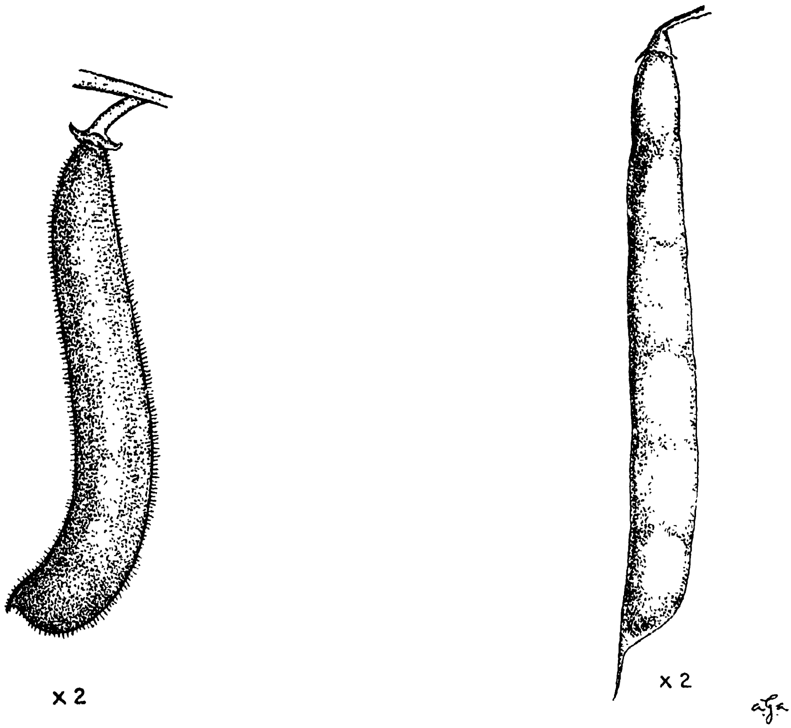

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FIG. 3—*Tephrosia villosa* PERS. (LEFT) AND
Tephrosia purpurea PERS. (RIGHT).

SOIL EROSION AND SOIL FERTILITY

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In order to appreciate the vital importance of reducing soil erosion to a minimum throughout Ceylon, it is necessary to accept the fact that Ceylon, being essentially an agricultural country, as opposed to an industrial one, is almost entirely dependent on agricultural production for her economic existence. Tea, rubber, coconuts and a few minor agricultural commodities are the primary source of her wealth. The soil on which these commodities are grown is the capital upon which Ceylon is dependent for the purchase of her outside requirements of raw materials and food.

Since Ceylon is not self-supporting, the rice and other foodstuffs imported to feed her population must be paid for from the capital derived from exports, which are almost entirely the produce of the land. Their production can continue only so long as the soil can continue to yield these crop commodities at an economic price ; in other words they must be produced and marketed at a cost which will enable them to compete with countries producing the same commodities. Provided the demand remains fairly constant and the price obtainable is reasonably remunerative, their supply is mainly regulated by their cost of production. This cost of production is influenced by a variety of factors, such as the price of labour, transport, &c., but the dominating factor of all, which determines whether production is economic or not, is *soil fertility*.

Soil fertility is to a large extent a measure of the productivity of a soil or, in other words, it represents the value of the crop that the soil can produce. It is not a measure of the degree of one particular factor relating to a soil, such as the quantity of available plant food, the organic matter content, its texture and moisture content, or the number and type of micro-organisms it contains ; rather is it a measure of the level of efficiency in crop production which is the result of the interaction of all these factors as influenced by external or environmental conditions, such as climate and cultivation.

Under natural conditions the degree of fertility attained by soils is extremely variable, and especially is this so in the tropics. Density of natural vegetation is not always a reliable

guide to the natural fertility of a soil; it can, in certain circumstances, be definitely misleading. Under natural conditions over a long period of years an equilibrium of soil fertility becomes established and, unless interfered with by man, there is no permanent removal of plant foods. For numberless years the existing natural vegetation has drawn its food requirements from the soil, but these are continually being returned to the surface soil by falling leaves, dying plants or parts of plants and other similar plant residues which, after decomposition, again become available for the existing natural plant growth. After a time, therefore, the natural vegetation provides its own food requirements in a cyclic process of growth, death and decay; a state of equilibrium is thus established.

Under certain favourable natural conditions, a slow and definite increase in soil fertility may take place, but if these conditions are interfered with the reverse is the case and the level of fertility will be decreased. As in all such cases, these katabolic changes proceed at a very much more rapid rate than those concerned in the building-up of fertility. Thus, when natural conditions are altered so as to make way for the artificial conditions of crop production, the fertility of a soil is immediately affected.

Agriculture essentially comprises the growing of certain plants in large communities, usually of a single type, the whole or some part of which is eventually removed in the form of a crop or a plant product of vegetable or animal nature. In this way large quantities of plant food are continually being removed from the soil and this loss entirely changes its natural equilibrium and rapidly lowers its fertility. However high the level of this fertility may have been, it is only a question of time before it is exhausted, since the fertility of a soil is maintained only until such time as the reserves it contains are used up and this, under tropical conditions, is not long, being at the most a period of a few years. Unless these reserves of soil fertility are built up and maintained, agricultural production becomes less and less remunerative until a stage is reached when the cost of production exceeds the value of the crop produced, and disaster results. This reduction in soil fertility is a cumulative process, the rate of which is accelerated with the passage of time.

The destruction of the vegetative covering of the soil is an unavoidable accompaniment of any form of change, not only from natural conditions to the artificial conditions of cultivation, but also in changes from one crop to another, whether permanent or short-aged. The removal of the protection, either in the form of the natural vegetation or of the crop itself, at once

exposes the soil to the tropical sun and to rain. The former has far-reaching effects upon the fertility of the soil. It causes the soil temperature to be raised and as a result the rate of oxidation and decomposition of organic matter is accelerated, with injurious effects upon the micro-organisms which make the soil their home. It also causes soil texture and tilth to be affected, enabling soil erosion caused by drying and wind to take place; fertility is thus immediately reduced.

The action of rain then comes into play, the previous processes contributing largely towards accentuating its effects. Rain water causes losses of soil and of plant food by erosion, and further changes and losses of plant food through leaching, for there are important differences between the physical and the chemical action of water upon soils. Erosion is entirely a physical action, the soil particles being removed in suspension in the water; leaching may involve chemical action, causing the removal of plant food by the water in solution: by both processes the fertility of the soil is still further reduced.

The raising of the level of the fertility of a soil, if economic results are to be obtained from its utilization for agricultural purposes, is a process that must be commenced from the very beginning and carried on throughout all time; otherwise the most profitable level of production will never be attained. This can be done only by the adoption of soil-conserving, intensive agricultural practices; crop production and plant and livestock utilization must go hand in hand if the best results are to be obtained.

Raising the fertility of the soil and maintaining it at a high level is the basis of the production of remunerative, healthy and economic crops and livestock. Soil fertility is entirely dependent upon the following conditions:—

(i) The prevention of soil erosion.

(ii) The maintenance of the organic matter content of the soil at a high level.

(iii) The maintenance of proper soil aeration.

(iv) The maintenance of a large population of the right types of micro-organisms in the soil.

(v) The maintenance of an effective soil moisture content.

(vi) The replacement of all plant foods removed from the soil by crops or livestock.

(vii) The maintenance of the soil in a condition of good tilth by means of the economic use of all land, labour and livestock.

(viii) The preservation and maintenance of the correct degree of acidity or alkalinity for the soil and crops concerned.

(ix) The absence or reduction to a minimum in the soil of all organisms and substances which are inimical to, or destructive of, plant growth.

Of the above, the first is obviously of primary importance, as unless a fertile surface soil can be conserved and retained *in situ* few, if any, of the remaining requirements can be permanently attained.

The term "soil erosion" means the loosening and removal of soil from its previous resting place, through any agency, and the first soil to be removed by the forces of erosion is the surface soil in which our crops are rooted and from which they obtain the bulk of their food requirements. Without this top soil certain crops may survive, and may even continue the production of what must usually be a low quality product, for a varying number of years at an uneconomic level. In most cases, however, no soil with any appreciable degree of fertility will remain, since few of our cultivated areas in Ceylon now possess any great depth of surface soil.

In many cases in Ceylon a sub-soil which is more resistant to erosion has already been exposed and various attempts to make it more fertile are in progress. These efforts, however, are unlikely to prove successful unless adequate arrangements are first made to conserve and retain this soil in position. It is possible that almost continuous and imperceptible sheet-erosion may prevent any progress being effected, and may even cause further deterioration, which is reflected either in the health of the plants or in standstill or reduced crops.

Wind and moving water are the two commonest agencies of erosion, others being variations, generally extremes, of temperature, and water in the form of ice or snow. In Ceylon wind and water are the two main causes of soil erosion and of these the latter is the more important.

Every owner and every cultivator of land in Ceylon, if he wishes to raise the fertility of his soil and maintain it at an economic level, should first take action to conserve this soil and protect it from erosion, and especially to safeguard it from the eroding force of surface run-off water. This protection mainly involves attention to the following points :—

1. The protection of the area from surface run-off water of external orgin.
2. The conservation either on the land or in the soil of that percentage of the rain water which falls on it which is the optimum for the soil and crops concerned in their particular environment.

3. The collection of any surplus run-off water in such a manner that it is practically free of suspended soil material, and at such intervals that its erosive action is negligible.
4. The removal of this collected surplus run-off water under proper control (*i.e.*, at a limited rate of flow) into safe and preferably natural drainage lines.
5. The maintenance of all natural and artificial drainage lines under a vegetative cover which is effective in preventing scour and erosion.

DEPARTMENTAL NOTES

BEE-KEEPING—THE MANAGEMENT OF A MODERN APIARY

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SELECTION OF SITE

IT is said that there is no spot where man can find sustenance that will not support a few swarms of bees. In Ceylon, although some places are more suited than others, bees are found under natural conditions both in the dry zone and in the wet zone from sea level to over 6,000 feet; even in towns bees are successfully reared. It may not always be practicable to select the ideal location for an apiary, but if the best results are desired the ideal should be aimed at as far as possible. It is generally believed that *Apis indica* flies to a distance of not more than half-a-mile from its hive in search of forage.

As the success or failure of an apiary depends to a very large extent on the presence or absence of natural vegetation, it is advisable to see that at least some of the plants described in *The Tropical Agriculturist*, Vol. XCI., 1938, pages 161–164, thrive in the locality. The number of colonies should necessarily be in proportion to the availability of bee-pasture. Even where sufficient bee-pasture is found among natural vegetation, it is expedient that the bee-keeper should plant some selected plants, so as to supply the bees with pollen and nectar during lean periods of the year. Bees flourish well in coconut estates and in fruit gardens, with benefit both to the plantation and to themselves.

LOCATION OF HIVES

Hives should be so placed as to get the sun from 8 to 10 in the morning and 4 to 6 in the evening. The morning sun is important as it makes the bees start work early. Excessive shade and intense heat are detrimental to the smooth working of a hive. The hives should face the East, under shady trees or under roofs. The distance between hives should be at least 6 feet. Hives should be placed on ant-proof stands and, if necessary, should be protected from high winds.

Antigonon leptopus, also known as the Mexican Coral Vine, Bride's Tears or Mountain Rose, can be trained on trellisses at reasonable intervals running from East to West. This is a beautiful flowering creeper than which there is no better nectar plant in Ceylon.

THE MANIPULATION OF HIVES

There is a common belief in Ceylon that bees should be subdued by smoke or otherwise before they are examined. With the Indian bee, this is not necessary. Local bees " respond kindly to kind treatment ". It is unreasonable to stand in front of a hive to open it. The bees which return from foraging will be disturbed and the interloper may be stung. In opening a hive, jerks should be avoided. Bees feel vibrations carried through solid bodies and they get excited. Sound does not affect them.

During the hotter part of the day, it is likely that the combs and brood will be adversely affected and it is, therefore, not advisable to open the hives at this time. Bees will not brook undue intrusion upon their offspring. On wet cold days, they prefer to remain indoors ; and for obvious reasons, they are in bad temper. They are never so contented as during the collection of pollen and nectar on hot sunny days. On such days, they may permit a certain amount of disturbance.

To open a hive, the roof must be gently removed from the rear. Then the super combs can be examined one by one. If the frames are pasted together with propolis, a knife will have to be used to detach them. The frames should be held at the two ends. After the combs have been examined, the whole super can be removed to examine the brood chamber. The frames of the latter should be examined in the same manner.

It is not uncommon to find irregular combs in a hive. These should be carefully removed with as little damage to them as possible, and replaced in correct position. The drone combs are always heavier than worker combs : they should be handled in such a manner as not to detach them from the frames. When a hive is opened, the bees come to the edges of the hive. Care should be taken not to crush such bees, not only because of the loss of bee life, but also because it irritates the others.

Bees in a queenless colony are most likely to sting. If they must be handled, they may be gently smoked. A suitable smoker is described in *The Tropical Agriculturist*, Vol. XC., 1938, pages 358–360. The principle involved in smoking is that when this is done the bees feel that there is some danger and quite naturally try to protect their valuable store, namely honey. To do so they have to drink it, and they drink so much

that their abdomens become distended with the result that they find it difficult to move about freely in order to sting. Tobacco smoke, popularly used by our villagers, is too strong and its use should be discouraged.

The fear of being stung is the greatest drawback to progress in bee-keeping. The sting is an instrument for self-protection and it will not be used by bees unless they are in imminent danger because they die immediately after stinging. The sting is barbed with recurved teeth and when thrust into the skin it cannot easily be withdrawn. Generally, each sting has three barbs on the sheath and ten on the lancets. Bees invariably leave behind some portion of the body attached to the sting.

A sting causes a certain amount of irritation and swelling, but this can be reduced to a minimum by gently pushing out the sting with a knife or the finger-nail immediately after being stung. Then the injured portion should be rubbed with some leaves of overpowering odour. This is a precaution against further stings.

There is a poison sac at the end of the sting and the poison is gradually injected into the system by the working of the "muscles" of the sting. Hence the importance of immediate extraction. The sting should never be pulled out for, if this is done, the sac bursts and the poison is released. If the swelling is considerable, a hot foment or a cold wet dressing may be applied. The best remedy is not to trouble about it unless the sting is near the eye, in which case some care has to be taken. It is popularly believed that one becomes immune to stings in the course of time. The writer knows of two men who have kept bees for over 15 years and they do not feel the effects of stings at all.

Bees make a careful survey of the surroundings of their hives and have the power of remembering them so clearly that they make a "beeline" to their hives when they are laden with pollen and nectar. If, while they are foraging, the hive has been moved further than three feet, they will find it difficult to locate it. Most of them will hover round the place where the hive had been when they left it and they will ultimately die of exhaustion. If, therefore, it is necessary to move a hive to another site, it should be moved not more than 3 feet each day, or it should be moved by night. When a hive has to be transported long distances, the entrance should be covered at night by a narrow strip of strawboard. It can then be moved on the following morning. If the distance is considerable, it is essential that the insects should be supplied with a reasonable quantity of sugar in solution.

THE INDIAN BEE

The question has often been asked why so much of trouble is taken over the small Indian bee when there are the more profitable European and American bees. The answer is that there is no need for foreign bees, because research on *Apis indica* has shown that this bee is capable of giving returns as profitable as her cousins in Europe or elsewhere. Foreign bees are very susceptible to diseases from which our bees are free. Experiments conducted by Hatch and his colleagues in the Travancore State have amply proved that the mind-set of the Indian bee is now changed. She was at one time known to be migratory in nature and a poor worker, but now there is definite proof that she is capable of storing a surplus of honey.

Indian bees prefer to remain in one place so long as that place is a congenial abode for them and for their stored-up products. A thoughtful bee-keeper should examine his hives once a week, rid them of any pests and make certain that there is plenty of food during the rainy weather. If he expects bees to live under the conditions provided for them, then he must see that all their natural requirements are given them. Otherwise they are liable to vacate man-made hives for a more natural life elsewhere.

The Indian bee is fortunate in that she is not liable to any serious disease, but she has often to contend with enemies. The bee-keeper should assist the bees by removing such objectionable intruders from the hives. Uncared-for bees are often menaced by wax moths, the larvae of which completely riddle the combs which have been so well constructed with so much labour. In spite of the water trough, ants find their way into the hives. They do considerable damage to the larvae and also drink honey. The red-and-black-banded hornets carry to their nests a large number of bees ; their nests should be located and burnt by night. Cockcroaches, lizards and spiders often make a comfortable home in the hives. They are all unfriendly to bees. The king-crow and other birds need to be watched for and scared away from the hives.

HOW SHOULD THE INDIAN BEE BE MADE PROFITABLE

In his book *Further Upward in Rural India,* Hatch says that " The method by which our bees are now made to work like the Italian, English or American bees, producing surplus honey for sale is very simple. It involves two principles : using the combs over and over again, and frequent extraction.

" In the primitive method of squeezing the comb to get the honey, the storage cells were ruined and before the bees could begin to gather more honey they had to make new combs. According to the best authorities, it requires 6 or 7 pounds

of honey to make one pound of wax comb. By the modern method of extraction by gently whirling the comb in a small centrifugal extractor (described in *The Tropical Agriculturist* Vol. XC, 1938, page 235) the combs are unharmed and can be placed in the hive again. What a saving of time and labour for bees! All they have to do is to refill the combs.

"A further increase in production results from one simple method of making bees work harder and harder continuously. We cannot wait as in the West for combs to be full. It is necessary for the bee-keeper to keep ahead of the bees. If he finds at his weekly examination that the combs are a little over half full he at once extracts all the honey from the super, putting the combs one by one into the extractor, whirling all the honey out, and returning them to the hive empty. Then bees quickly collect more.

"The mind-set of the Indian bee has been changed. When we have made them conscious of the need of working, they can do work faster than the Western bees."

Last year the writer had the good fortune to make a survey of a village in South Travancore for the purpose of taking a stock of bee-keeping. The investigation revealed that there were nearly 300 families which owned over 1,000 hives. From these, the apiarists were able to get an increased income of Rs. 3,000. Some of these families live mainly on bee-keeping for they have no land to cultivate and there are a very few wage-earning vocations. There was one man who was able to save Rs. 150 from the proceeds of 31 hives in one year.

When honey is removed before it is ripe, that is, before all the cells are capped, it contains a certain quantity of moisture which must be removed before bottling. Moisture causes fermentation. The method of artificially ripening honey is described in *The Tropical Agriculturist,* Vol. XC., 1938, page 236.

Honey is an invaluable food ; its sugar is in an easily assimilable form and is superior to other sugars. It is regularly used in Ayurvedic medicines and there are many Western physicians who prescribe it. Some believe that honey has astringent properties. This is a myth. It can be taken even by diabetic patients. According to the analysis of the Government Agricultural Chemist, Coimbatore, honey contains 14·89 per cent. water, 0·47 per cent. ash, 73·96 per cent. reducing sugars, and 5·84 per cent. sucrose.

ECONOMICS OF BEE-KEEPING

With the co-operation of certain bee-keepers, an effort is being made to determine the economics of bee-keeping under Ceylon conditions. The figures so far obtained, though

encouraging, are yet too incomplete for discussion. The figures quoted below are, therefore, obtained from a paper read at the Association of Economic Biologists at Coimbatore, in 1933. Bee-keeping in Coimbatore is on the same lines as the work conducted by the Propaganda Division of the Ceylon Department of Agriculture.

During one year, 11 hives yielded 118 lbs. of honey which realized Rs. 148 at Re. 1·25 per lb. Each one of these hives gave out a swarm which in turn yielded Rs. 77 worth of honey. Thus in one year the total income was Rs. 225. The cost of these 22 hives, at Rs. 4·50 each, and the honey extractor, costing Rs. 6, came to Rs. 105. The initial cost of hiving the original 11 colonies was Rs. 22. The total outlay, therefore, was Rs. 127. The interest on the investment at 7½ per cent. comes to Rs. 9·75; the hives and the extractor are expected to be useful for at least 15 years, hence the annual depreciation will be about Rs. 7. The cost of supervision is negligible since the bee-keeper himself is expected to attend to the work. However, it may be put down as Rs. 10 for the year. The total annual expenditure, therefore, amounts to Rs. 30 approximately. Deducting this amount from the income, the profit realized amounts to Rs. 195, thus making an average nett profit of Rs. 20 on each hive.

In Ceylon, hives with one super can be turned out at about Rs. 2·50 each, and the extractor costs Rs. 5·40. The initial outlay is, therefore, less than at Coimbatore. We have more and better bee-pasture throughout the year. It can, therefore, be presumed that bee-keeping in Ceylon will give results at least as profitable as those of our neighbours across the Palk Strait.

NOTES ON VEGETABLE TRIALS AT LOVER'S LEAP, NUWARA ELIYA

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ALTHOUGH the area available for vegetable trials at Lover's Leap is very limited, the following results are those obtained during the last few years. As space becomes available, trials with other vegetables, especially those not commonly grown in Nuwara Eliya, are to be undertaken.

Seed of practically all varieties can be sown throughout the year except during the months of June and July when the weather is usually far too wet for this work, unless provision is made for the protection of the seed beds by means of lean-to sheds roofed with either thatch, cadjans or corrugated iron sheets.

During the south-west monsoon it is very seldom indeed that crops of peas, beans, vegetable marrows, &c., which depend on good weather for the setting of the flowers, can be produced, owing to the prevailing strong winds and wet weather ; and even root crops rot in the ground during this period.

Cut-worm has always been troublesome and we have yet to find a suitable remedy for controlling this pest.

The club-root disease of cauliflower, cabbage, &c., makes the successful cultivation of these vegetables, and others of the same order, very difficult. Even on new ground the disease soon makes its appearance.

No crops of the cabbage order (*Cruciferae*) should be grown on the same ground for at least three years and heavy dressings of lime should be applied when making preparations for planting.

A soil cleanser which is recommended for use in the control of club-root and cut worms is at present under trial and it is hoped that the results will be satisfactory.

Another handicap with which we have had to contend has been the damage done to crops by hares and mouse deer. Wirenetting to protect plots of any special vegetables under trial has been procured and we should, in the future, be able to obtain more definite and useful results.

The following notes on the various vegetables under trial are given :—

Beet.—Several varieties have done very well. Seed can be sown practically throughout the year either in drills and the seedlings thinned out to at least six inches apart, or in beds and the seedlings transplanted as soon as they are about four inches in height. Rows should be 12-15 inches apart. In both cases the ground requires to be well dug and only well-rotted cattle manure should be used in its preparation.

When the crop is harvested, great care should be taken not to damage the roots; otherwise, bleeding will result in the spoiling of the colour. The leaves should be cut at least 3 inches above the top of the root or removed by twisting them off.

Of the turnip-rooted varieties those recommended are " Globe " and " Crimson Globe ", and of the long varieties, " Blood Red ".

Cabbage.—Although most of the cabbages grown in Nuwara Eliya are raised from cuttings obtained from the stumps after the cabbages have been cut, they should be grown from seed as plants so grown are more tender and, therefore, more suitable for the table.

The seed should be sown in drills or prepared beds and the seedlings planted out, when about 4-6 inches high, in well-dug and manured ground 12-15 inches apart in rows 18-24 inches apart, according to the variety.

Owing to the liability of the plants to attack by club-root, they should not be grown on ground following a similar crop, or a crop of cauliflower, Brussels sprouts, Kohl-rabi and turnip, for at least three years.

Varieties recommended are " Maincrop ", " Drumhead ", " Flower of Spring " and any of the Savoy varieties.

Carrot.—A number of stump-rooted and long varieties have been under trial and nearly all have produced good crops.

The seed should be sown thinly either broadcast or, preferably, in drills 9-10 inches apart. The seedlings should be thinned out to 4 inches apart in the beds and along the drills as soon as they are large enough to handle.

This crop can be grown in almost any ordinary garden soil, but if roots of good quality are required, it is essential to dig the ground deeply and to see that it is thoroughly cultivated. A good dressing of lime or ashes should be given, and only well-rotted cattle manure, which should be well broken up and buried about a foot deep, applied; otherwise the roots are apt to " fork " and so become unsatisfactory for marketing.

2——J. N. 1949 (1/39)

When harvesting, the tops should be cut close to the crown.

The roots can be stored in sand or dry earth in a cool shed, for several weeks if necessary, but should not be washed before storing.

Varieties recommended :—" Early Horn ", " James' Intermediate ", " Scarlet Intermediate ", " Early Gem ", " New Red Intermediate ", " Autumn King ", " Chantenay ", " Long Red " and " Long Stump ".

Cauliflower.—Good crops of several varieties were grown soon after the plot was opened but, during the last few years, club-root has been very troublesome and this has been the case throughout Nuwara Eliya in vegetable gardens which have been run for a considerable time.

As mentioned above, a soil cleanser which is well spoken of as a control for this disease is under trial.

To reduce the incidence of club-root, cauliflowers should not be grown on the same ground for at least 3 years and then only after a heavy dressing of lime.

The seed should be sown thinly in prepared beds made up of moderately rich soil, the seedlings being pricked out 4 inches apart, when large enough to handle, and finally planted out, when about 6 inches high, from 18 inches to 2 feet apart, in well dug and liberally-manured ground. When the plants have made good growth, a dressing of nitrate of soda, at the rate of 2 ounces per square yard, will be found very beneficial.

As soon as the heads begin to form, a couple of the surrounding leaves should be broken over them to protect them and prevent them from becoming discoloured.

Varieties recommended :—"Early Giant ", " Autumn Giant ", and " Autumn Mammoth ".

Celery.—We have not yet been very successful with this crop and further trials are in hand. Excessively wet weather experienced during the trials so far undertaken has resulted in the plants rotting off in the trenches.

A good, free, open soil is essential for the successful cultivation of this vegetable and no attempt to grow it in a wet, clayey soil should be made.

The seed should be sown thinly in a well-prepared, protected bed, the seedlings being pricked out when large enough to handle, and the final planting should be done in trenches a foot deep, with the plants a foot apart in either a single or double row.

The larger leaves should be removed before planting out and the roots disturbed as little as possible.

The plants require to be earthed up as they grow and, before the final earthing, should be tied to prevent soil entering the hearts.

·Varieties recommended :—" Solid White " and " Giant White ".

Kohl Rabi. —A useful crop to grow during dry weather when turnips are apt to become dry and woody. The seed should be sown in prepared beds or drills, the seedlings being pricked out and planted, when about 4 inches high, in well-worked and manured ground, 9 inches apart in rows a foot apart.

This crop is subject to club-root, and precautions should be taken as given above.

·Varieties recommended :—" Short-top Green " and " Earliest Purple ".

Lettuce.—So far only the cabbage variety has been grown but the Cos Lettuce should also be cultivated. The seed should be sown thinly in well-prepared beds, the seedlings being pricked out when large enough to handle and planted 12 inches apart each way in well-dug and well-drained ground which has been given a good dressing of cattle manure. If space is restricted, they may be grown along the edges of beds and between rows of cauliflower, Brussels sprouts, &c.

Varieties recommended :—" A.1.", " Iceberg ", " Salamander ", " Matchless " and " Golden Ball " in the cabbage group, and the following Cos varieties—" White Heart " and " Mammoth White ".

Onion.—The growing of this vegetable has so far proved a failure. Onions require much drier conditions than those obtaining in Nuwara Eliya and should be grown at medium elevations. Further trials, therefore, are not recommended.

Peas.—These have done very well and a number of varieties have been under trial.

For the best results, the ground should be deeply worked and enriched with well-rotted cattle manure and the soil well broken up before the seed is sown.

Lime is essential for successful growth and care must be taken not to apply too much rank manure as this will result in an over-abundance of foliage at the expense of a good crop of pods.

The seeds are sown every 3 inches in 2 rows, 6 inches apart, in flat drills 12 inches wide, and covered with about 2 inches of soil. These double rows should be from 3–6 feet apart, according to the variety.

Brushwood supports shoud be provided as soon as the plants are about 6 inches high and they should be staked a few weeks later.

For growing on a large scale, dwarf varieties are preferable as so much less staking is needed.

Varieties recommended :—" William Hurst ", " English Wonder ", " Yorkshire Hero ", " Duke of Albany ", " Green Feast ", " Lord Chancellor " and " Abundance ". The local, small-podded village pea is strongly recommended.

Potato.—The successful growing of this crop depends a good deal on the weather. A few days of wet, dull weather often cause the rotting of the tops which are also liable to be burnt badly by frosts. To prevent damage by frost, the rows should be covered with cadjans at night. This, of course, can only be done when a small area is in cultivation.

The best time for planting is between mid-December to the end of January, the tubers being planted a foot apart in well-manured trenches, 6 inches deep, and covered with about 3 inches of loose soil. The trenches should be 3-4 feet apart according to the variety and space available. The plants should be earthed up during growth and harvested as soon as the tops begin to die down.

For storing, the tubers should not be washed. Most of the adherent soil should be removed by hand, care being taken that the skin is not damaged. The tubers should be stored in a cool room.

Varieties recommended :—" Majestic " and " Great Scot ".

Spinach.—The best variety is the " New Zealand " which can be grown from either seeds or cuttings. A condition conducive to good growth is a deeply dug, moderately rich soil and, when once established, the crop yields well for several months, provided the weather is not too dull and wet, when the tops are liable to rot.

When the seedlings are about 4 inches high, they should be planted out 18 inches apart each way.

Turnip.—This has done very well and requires a well dug, moderately rich soil and should be sown in drills about an inch deep and 12–15 inches apart. As soon as the seedlings are large enough to handle, they should be thinned out to 6 inches apart.

Lime should be used freely when preparing the ground which should be broken up well before sowing.

During dry weather, turnips are apt to become stringy and woody if frequent waterings are not given. They should be harvested when quite tender.

Varieties recommended :—"Purple Top ", " Early Snowball", " White Milan " and " Golden Ball ".

Vegetable Marrow.—This is a vegetable which is not worth attempting to grow during the rainy seasons owing to the liability of the flowers fruits, and plants to rot.

Three or four seeds should be sown a foot apart on a mound of rich soil and the stems pegged down as they grow. When the leading shoot has attained a length of about 6 feet, it should be pinched off at the tip.

If the flowers do not set readily, artificial pollination should be resorted to.

Plants can also be raised in medium-sized pots or supply baskets and planted out as soon as they have become large enough to withstand the attack of cut-worms. Frequent waterings should be given during dry weather and liquid manure applied at least once a week.

Marrows should not be allowed to grow to full size as this results in the cropping capacity of the plants being reduced. They should be cut when they attain half their normal size, if superior quality is required.

Varieties recommended :—" Long Green " and " Long White ".

SOIL CONSERVATION

THE following memoranda were submitted by the Agricultural Officer, Soil Conservation, for consideration by the Conference of Colonial Directors of Agriculture held in London, from July 25 to 30, 1938. As they may be of general interest to readers of *The Tropical Agriculturist* they are reproduced below. (Ed. T. A.)

I. THE PROBLEM OF SOIL CONSERVATION IN CEYLON

In Ceylon, the main type of erosion on land under cultivation is sheet-erosion caused by intensive falls of rain, often of brief duration. While other types of erosion occur, the areas affected are comparatively limited and their effects so much more conspicuous that they usually generate both recognition and some attempt at control. Wind erosion, gullying, bank erosion, rill erosion and, what is locally termed " dry wash " which is really gravity-erosion, comprise the main subsidiary types. Sheet-erosion, however, remains the chief form of erosion which requires both wider recognition and extended measures of control.

This form of erosion usually results either from the rapid movement of surface run-off over steep slopes of limited extent, or its more sluggish progress over a considerably greater distance. In both cases, it is that fractional part of the rainfall which results in the rapid accumulation of excessive quantities of surface run-off, and it is this extra quantity of water, the controlled removal or temporary storage of which must be provided for to prevent loss of both soil and fertility. To effect the necessary control contour works are recommended, the distance between these being governed by the gradient, the soil and the crop concerned.

The main type of contour work advocated is a contour lock-and-spill drain with a low, vegetation-covered bund sited on its upper side, so that any erosion which occurs has a terrace-forming and gradient-reducing effect. In this connexion, not only has the subject of water disposal to be considered, but also that of malaria control.

The retention, in the locks of the contour drains, of the optimum quantity of water for the soil or crop can be regulated (and even varied where necessary) by the height of the blocks or spills when facilities exist for the removal of surplus by lateral spill into natural drainage lines or main down drains.

Where the retention of a maximum quantity of water in these drains is desirable or unavoidable, it is recommended for anti-malarial reasons that these lock-and-spill drains be converted into a series of sponge trenches along the same contour, separated by the spills or blocks, by maintaining a certain depth of humus (derived from fallen leaves or periodically-cut green material) in each of the locks. For reasons of economy, as well as to reduce the time during which water stagnates in the drains, it is now recommended that such contour drains be shallow, be cut with sloping sides, more or less half-hexagon-shaped in cross section but with a wide top and a narrower bed or base. This shape is considered to make the best provision for the controlled disposal of the greatest quantity of water per foot of depth. Compared with drains of equal depth having vertical sides it increases capacity, facilitates the escape of soil air displaced by moisture absorbed, reduces the erosion of the drain-sides to a minimum and encourages the growth of protective vegetation on them. A wide surface and sloping sides reduce the cost of excavation and provide a larger surface for evaporation. Anti-malarial measures consist of converting these drains into contour lock-and-spill sponge trenches, by maintaining an adequate supply of humus in the locks, and of shading the drains by establishing a suitable type of vegetation on their berms. The latter has the additional advantage that it protects the drain from the direct beating action of rain and prevents damage to the drain caused by cultivation right up to their edges.

The only disadvantage of this system of erosion control lies in the reduction of the cultivable area which its adoption involves. With wide-spaced crops, such as rubber or coconuts, this loss is not very material but on steep land cultivated in annual or seasonal crops it may be considerable. This, however, is the penalty which has to be paid to conserve the soil on land the slope of which is not suited to the type of crops being cultivated.

On rocky areas, where the excavation of such drains is impracticable, contour works, such as low walls or hedges, with a reduced contour interval are regarded as essential for almost all types of cultivation. They are especially necessary for areas which have no definite outlet and right of way for their surplus run-off water, since, to prevent damage to neighbouring property, the movement of this water has to be checked at frequent intervals in such a manner that it carries little or no soil with it and that its velocity is reduced to a minimum before it leaves the area concerned.

Widespread efforts are being made by propaganda and example to get agriculturists to regard the conservation of

their soil as a necessary preliminary to all forms of cultivation. It will take some time to wean agriculturists from the habits of centuries of soil-deteriorating cultivation. The example being set, however, is being followed by a number of the more intelligent cultivators of small areas, and there is no doubt that a growing nucleus of this type of cultivator is becoming more and more erosion-minded.

II. SYSTEMS OF LAND SETTLEMENT WITH SPECIAL REFERENCE TO THE CONSERVATION OF THE FERTILITY OF THE LAND

Visits to a number of peasant settlements have indicated the necessity of consideration being given to the conservation of the soil of these areas, even in advance of their alienation and the clearing of the vegetative cover. A point of primary importance is strict adherence to the rule that no land having a slope of 45°, or more, shall be alienated unless such land forms a portion of a large block having generally a slope of under 45°. Even in cases where land is alienated under the latter clause, it would appear to be necessary, in the majority of cases, to prohibit the removal of the natural vegetation from those parts of the areas which have a slope of 45° or more, and also to prohibit the clearing of all natural drainage lines within the area, if serious damage from erosion is to be prevented.

A further difficulty is often presented in the selection of sites for peasant settlements, especially in areas of comparatively low rainfall. The idea that a tropical forest indicates a fertile soil still tends to predominate; too often it covers a multitude of rocks interspersed with a few pockets of deep soil. The direct dependence and effect of vegetation upon climate still appears to be insufficiently appreciated. The close relation which exists between volume of run-off water and density of vegetation, and the high percentage of the rainfall which becomes surface run-off on uncultivated soil under a grass cover, are rarely recognized sufficiently.

In the clearing and opening up of new land, the necessity for maintaining natural drainage lines under a cover of vegetation has already been referred to, but it is felt that emphasis should be given to the fact that this is intended to relate to both minor depressions, which serve as water-courses during wet weather only, as well as to perennial streams. In the construction of soil conserving contour works there is a distinct tendency to neglect or even to close up these natural relief systems, instead of employing them as safe-conducting channels for that fraction of the collected run-off which is surplus to the requirements of the land and crop. The greater the number of these natural drainage lines the greater, usually, is the need for them, and especially is this the case when land is first cleared. When their

clearing has been inadvertent or unavoidable, they should immediately be permitted to become revegetated and, if necessary, this process should be artificially encouraged and expedited.

A further point in the clearing or blocking out of land for settlement is the early recognition of the extremely high percentage run-off which takes place on areas of rock or of low absorption. Such areas should invariably have a protective belt of vegetation left, or established, around them to safeguard the adjoining land.

In the arrangement and blocking-out of the individual allotments of a settlement, arbitrary or artificial base lines should be avoided. Each allotment must be provided with an outlet for surplus surface run-off, and a right of way for this water, into a natural drainage line, along a course which will prevent it causing erosion on either undeveloped lots or the adjoining land. The following alternative schemes of arrangement are suggested for the siting of the lots in a settlement on land with any degree of slope. The first is for the lots to be contiguous along alternate contour strips with a common storm-water drain above and below each cultivated contour strip, the alternate strips being maintained in natural vegetation. The second arrangement suggested is to regard all main natural drainage lines as the middle line of a herring-bone system, the side lines of which are the lateral lines of access for surplus water to the main natural drain. These side lines, between which a series of contiguous lots may be disposed, radiate back up the hill at an angle which is more or less acute according to the slope of the land. In this way the natural drainage lines, protected by the existing or even an improved vegetative cover, then become the backbone of a soil-conserving, more or less contour, settlement system. The not infrequent chequer-board arrangement of settlement lots, on hillsides which often have an appreciable degree of slope, is to be deprecated and should give way to a planned design based on soil conserving lines.

SELECTED ARTICLES

POULTRY—CARE OF GROWING STOCK*

IF pullets are to stand up to the strain of continued egg-production and prove good-breeding birds they must, in addition to possessing inherited vigour, constitution, and egg-producing power, be given proper care and attention during their growing period.

It is not difficult to rear a few pullets successfully, for when kept in small lots growing stock are not overcrowded and get ample fresh air, warmth at night, and plenty of food from the time they are hatched. However, to rear successfully several hundred pullets, the majority of which will produce a profitable number of eggs for two laying seasons, calls for special and constant attention to many little details that can best be learnt by practical experience and the close observation and application of a successful man's method.

Many pullets which lay well enough during their first six or seven laying months are reared each year, but too many fail to be really profitable for a longer period.

VALUE OF ENVIRONMENT

The beginner, at times, fails to appreciate the great importance of correct environment, and tries to build up his flock before he gains the necessary experience. Good eggs, day-old chicks, or perching pullets may be purchased from a reliable breeder, but if a number of these fail to come up to expectations during their growing or laying period there is often a tendency to blame the seller, when the real cause is due to some mismanagement through lack of experience and a thorough knowledge of the full requirements of growing stock.

NORMAL DEVELOPMENT

Some poultry-keepers are inclined to under-feed the early hatched birds slightly in order to check them from coming on too soon or to overforce the later pullets in the hope of bringing them on. Such methods are a mistake, especially if carried too far, for experience has proved that steady normal development will give the most satisfactory results and that any deviation from natural development has a tendency to reduce vitality.

When birds are reared on the intensive system it is even more necessary that management be of the best and all little details be regularly attended to, for the further we get from nature the more skill and close observation is required to be successful.

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* By C. J. C. Cussen, Chief Poultry Instructor, Wellington, in the *New Zealand Journal of Agriculture*, Vol. 57, No. 5, November, 1938.

It is true that early hatched chicks grow faster and better and are usually much less trouble to rear than those hatched later. This is no doubt partly due to the fact that the early chicks get much more rest during the longer nights of late winter and early spring and that they seem to do better during cooler weather. To retard their natural development by under-feeding, however, has not proved the most profitable procedure.

FEEDING

After the first few days it is difficult to over-feed growing stock. They require plenty of good, plain food, and this should be given at regular times and should consist of as much as they will clear up without waste. With early hatched birds it is advisable to reduce the amount of animal feed being fed to about 5 per cent. between the ages of three and five months, but it is wise to keep up the supply of good feed to provide growth.

With the later hatched birds an extra feed of mash each day will often assist development, but, as already indicated, to overforce with animal feed has a tendency to reduce vitality.

At times, growing stock seem to go off their feed, especially between three and four months old, and they will sometimes leave their grain or mash. This need not cause much concern, but it is advisable to try to get them back on their feed as soon as possible. A change to a fresh house or pen sets them up, or a little extra of what they are cleaning up and a little less of what they are leaving, or some extra succulent green food, has often sharpened up appetites.

THE START OF LAYING

Well-reared utility pullets should come on to lay between five and a half and six and a half months. In almost every flock, of course, there will be some precocious pullets that will come to maturity and start laying at about four and a half months old. Such birds are seldom very profitable, as they have matured before their frames have had time to develop, with the result that they are usually small and lay small eggs. Such birds should not be used for breeding.

If only 1 per cent. or 2 per cent. of a flock mature at that early age it should not cause worry, but where too many birds start laying at too early an age and the average size of the birds is not being maintained it would indicate that either too much animal feed has been fed or that nature is sending a warning that selection for egg-production has gone a little too far, and that more care regarding size and breed characters when selecting breeding-birds should be given in the future. Also, some fresh blood may be required.

If utility birds are seven and eight months old before they start to lay it would indicate that insufficient feed has been given during their growing period. Growing stock show the result of mismanagement more quickly than adult birds. The well-reared flock will always be even in size and very active and will show that desired healthy strength and ruggedness. It is well to remember that in the production of strong, vigorous young stock care and feeding are even more important than breeding.

FRESH AIR

As young stock get older they require more perching space and fresh air to enable them to make that desired normal development, but if they are compelled to roost in overcrowded or poorly ventilated houses they cannot build up that strength and health so very necessary for continued egg-production and disease resisting power. One of the greatest advancess in poultry culture is the realization of the great importance of fresh air.

Our most popular canopy type of brooder, under which three hundred to four hundred chickens can be brooded successfully, owes its success largely to the fact that the chickens get plenty of fresh air as well as a regular amount of warmth. The most successful up-to-date fowl-houses have plenty of height and depth and more or less open fronts, in addition to back ventilation.

Moisture is constantly being given off from the bird's body by means of their breath and faeces, and unless the house is well ventilated the air seems to become damp and unhealthy. It has been estimated that one hundred hens will give off 3 gallons of moisture in twenty-four hours.

W. A. Lippencott, in his book "Poultry Production", makes the following observation regarding this matter :—

> Ventilation in the poultry-house is important for the purposes of removing moisture, and to supply the air requirements of the fowls. Although air requirements cannot be stated specifically in terms of a definite minimum it is interesting to note that Colin, a French physiologist, is quoted by King (1910) in respect to air breathed by different animals per 1,000 lb. live weight each twenty-four hours as follows :—

	Cubic Feet.
Cow	2,804
Horse	3,401
Sheep	7,259
Hen	8,278

It is difficult to house fowls so that they will have the same full advantage of fresh air as they have in the tree and at the same time be protected from draughts.

While a fowl can roost all night in a tree when it is blowing a gale and not take cold or suffer any other noticeable ill effects, it will take cold very quickly if compelled to be in a draught inside a house.

These points are mentioned in order to stress the great danger of overcrowding and the importance of fresh air.

REARING DUCKLINGS

The same principles apply when rearing ducklings. They must have plenty of fresh air at night; in fact, they require more than chickens of the same age, and they require more animal feed in their rations than chickens.

CULLING PULLETS

As only birds sound of body and of good constitution are likely to stand up to the strain of continued egg-production and prove profitable, it is advisable to cull all those not likely to measure up to requirements.

The most experienced and successful poultry-farmers get culls among their pullets, but their success is largely due to the fact that they are always on the watch and adopt a regular system of culling throughout the year. Any birds showing a weakness or stunted growth should be culled.

A tail carried with a downward slant, or what is known as a "dropped tail", indicates a weakness, and birds showing such a weakness are better removed. The beak should be examined, and if any are twisted or deformed the birds are not likely to be profitable. Birds with twisted backs or other deformity should be culled. If a bird is much thinner and narrower than the majority it indicates weakness.

Birds showing any bad breed defect are better out of the flock.

Above all, never keep the stunted stragglers, for they are a danger to any flock and often start an epidemic of colds, worms, or some other trouble.

FACTORS AFFECTING THE SETTING OF FRUITS*

INQUIRIES are frequently received from orchardists concerning the failure of certain of their fruit varieties to set and bear fruit. Information is sought as to the cause of this unsatisfactory condition and suggestions for remedial treatment are requested.

The bearing and setting of fruits is capable of being influenced by a number of different factors, some of them extremely complex. Some of the conditions responsible for poor yields can be avoided or influenced by treatment or management, others are beyond control. In this article consideration is given to factors which commonly result in sterility or partial cropping.

The main factors affecting fruit setting may be roughly classified into five main categories, namely, meteorological, pathological, nutritional, sexual, and agencies affecting pollination.

METEOROLOGICAL CAUSES

Weather conditions experienced at the time of blossoming are perhaps the most important factor affecting the setting of fruits.

When a period of calm, warm sunny weather synchronizes with the blossoming of any particular fruit, a good set is assured. Rain with cold wind is prejudicial to effective pollination, limiting the activity of bees and other insects, whilst excessive humidity will prevent pollen from ripening and reaching the fine condition necessary for its dissemination. Frosts are also responsible to a large extent for crop failure, expecially amongst the early blossoming drupe fruits such as cherries, plums, and apricots. Frost injury may be prevented by the artificial heating of areas by means of orchard burners with which the atmospheric temperature is kept above the danger point, but no economic treatment can be recommended to combat the effects of cold, wet, windy weather.

PATHOLOGICAL CAUSES

Fungus and insect pests are often directly or indirectly responsible for serious injury to flowers during the blossoming period. During recent years in Tasmania this has been particularly noticeable in our pear varieties, many of which have been affected by the black spot fungus at this stage.

The fungus attacks the stalk, sepals, and portions of the flower, thereby inhibiting development and generally causing injury or death of buds and flowers. Powderly Mildew is also responsible for the loss of numerous blossom buds in heavily infected orchards.

* By P. H. Thomas, Chief Horticulturist, in *The Tasmanian Journal of Agriculture*, Vol. IX., No. 4 (New Series) of November 1, 1938.

The brown rot fungus is often very troublesome during the blossoming period of apricot and other stone fruits, although it is seldom found on apples and pears. In each instance recommended preventive fungicidal sprays applied at the correct period should protect the blossoms from infection. Tasmanian orchardists are indeed fortunate in not having to combat the disease known as Fire-blight that is prevalent in U. S. A. The bacteria of this is spread very largely by the honey bee and other insects during the blossoming period, making the problem of control exceedingly difficult.

Amongst the insect pests thrips must be considered the most important. Here again Tasmanian growers have not suffered to the same extent as their competitors. This insect attacks the floral organs, destroying the pistil and stamens. In Western Australia and Victoria thrips have been responsible for almost the entire destruction of fruit crops in some districts. The species causing the injury are found in this State, but fortunately climatic conditions are generally unfavourable to its operations.

Other insect pests such as pear mite, aphids, red spider, and tortrix caterpillars cause a certain amount of injury during fruit setting, but none of these have yet proved to be of economic importance in this respect.

NUTRITIONAL CAUSES

Experiments have demonstrated that in many cases fruit setting is materially affected by the lack or over-supply of plant foods. The age and condition of the tree is most important and deserves careful consideration. Varieties differ considerably in their growth and cropping habits.

The formation of healthy fruit buds is largely dependent upon a proper balance being maintained between the carbohydrate and nitrogen content of the tree, and if this balance is upset production is affected.

Any treatment such as the excessive use of nitrogenous fertilizers or severe pruning, both of which cause undue stimulation and increased vegetative growth, may affect the development of fruit buds, whilst over-cropping and lack of the requisite plant food will often produce unhealthy blossoming and eventually result in biennial cropping.

Pruning is closely related to nutrition and in many cases the producer is meticulously adopting methods of pruning which are opposed to the manurial programme. Thus we often see vigorous trees severely pruned and receiving heavy applications of nitrogenous fertilizers. The resulting crops are generally sparse and the fruit is oversized. In other instances light pruning may produce heavy crops, and unless thinning is carried out in conjunction with heavy fertilizer applications cropping in alternative years may result.

Unsatisfactory pruning methods give rise to a surprising number of partial crop failures. This is particularly evident in some species of apple, peaches and pears where the pruning has been conducted more on the lines of an annual grooming than an aid to fruit bud formation, and a large proportion of the bearing wood is regularly shorn off to improve the tree's general appearance.

Inadequate drainage is another cause which frequently affects the setting of fruit crops.

Excessive rains occurring at or previous to blossoming may saturate the soil to the extent that the newly developed capillary feeding roots commence to die off or decay. This results in a partial cessation of growth during a critical period. In some cases fruit setting only is affected, whilst if the period of growth cessation is prolonged a sap fermentation may result which ultimately causes death or serious injury to the tree.

SEXUAL CAUSES

Most growers who have made only a cursory study of fruit setting will realize the important relationship between the fruit and the seed; in fact, the edible flesh that is produced is dependent almost entirely on seed formation.

Seed formation can only take place where pollination has occurred. The importance of effective pollination will thus be fully appreciated; and amongst the adverse causes influencing setting ineffective pollination is perhaps the most general in our pome, drupe and berry fruits. The deciduous fruits grown in Tasmania may, for the purpose of this discussion, be divided into two classes, namely, those which are self-fertile and those which require cross-fertilization.

Varieties which are self-fertile bear perfect flowers possessing normal male and female organs, the pollen of which is functional.

Pollination in such varieties may occur as a result of natural flower development or be assisted through the agency of insects.

The value of such varieties lies in their being able to produce crops when planted in large areas and there is not the necessity to introduce other varieties for cross fertilization.

The necessity for cross fertilization of certain varieties is due to a number of causes; the flowers of some fruits are imperfectly formed and normal fertilization cannot take place. This is especially evident in some varieties of strawberries whose flowers are almost entirely pistillate or staminate. In some species the pollen produced is often sterile, which prevents either self-pollination or the fertilization of other varieties. A peculiar phase of these species is that they are highly receptive to cross fertilization from a compatible variety, and where this occurs produce heavy crops of fruit.

Sterility as the result of incompatibility is very prevalent amongst apples, pears, plums and cherries.

In the early stages of the development of the fruit industry, the demands of the market were not nearly so well defined as in later years, and almost any fruit of medium quality with a fairly attractive appearance would sell readily. Under such conditions the planter exercised a wide range in the choice of varieties for his orchard, incidently providing greater chances for effective cross fertilization in self-sterile kinds. As the industry developed the retail trade and the consumers learned to know the value of different species and the planting trend became confined to these.

Under the conditions large single blocks of popular fruit species were sometimes planted, and it was at this stage that the necessity for effective cross-fertilization became apparent if regular and profitable crops were to be produced.

The orchardist to-day generally realizes the necessity for providing means of cross-fertilization, especially in certain pome and drupe fruits, and during recent seasons many intending planters have availed themselves of the information collated by the Horticultural Division of the Department of Agriculture on this subject before setting out new areas. A simple method of testing areas in which imperfect fertilization is suspected as the cause of unfruitfulness is to carefully select a number of trees and artificially cross-fertilize limbs on each with a variety of blossoms at approximately the same period. This can either be performed by hand or by placing sprays of blossoms in jars of water suspended from the main limbs. By this method an indication can first be obtained regarding the compatibility of each of those selected with the variety.

During the ensuing season grafting or budding of the kind that has proved most effective to ensure the necessary cross-fertilization can be undertaken. In planting large areas the general practice where two or three varieties are to be grown is to arrange the planting in alternate rows of four. This also gives facilities for harvesting, spraying, and any particular treatment.

Where large blocks of one or two varieties are necessary the general practice is to plant the pollinators at regular distances throughout the area, which will enable effective cross-fertilization of the trees in their vicinity to take place.

AGENCIES AFFECTING CROSS-POLLINATION

Contrary to general belief, it has been found that wind is not an influential agent in the pollination of most deciduous fruits.

The work is mainly performed by insects, of which the bee is the most important. Honey bees work best at the higher temperatures—60° to 70° Fahr.—and on cold, wet days, even though the trees may be in full blossom, and in close proximity to varieties suitable for cross-fertilization the set of self-sterile kinds will be affected.

It will be seen that although bees are a necessary adjunct to fruit setting in every orchard, under certain conditions when weather is unfavourable they cannot be entirely relied on to effect the necessary cross-fertilization. It is opportune at this juncture to discuss briefly the general spray programme in its relationship to fruit setting.

Every encouragement should be given to the bees to work amongst the flowers during the blossoming period. Growers generally realize the importance of this and refrain from applying sprays, between the pink and the petal fall stages of development, which may act as deterrents to the bees.

During recent years propagators have directed research work towards evolving fruit varieties that do not require pollination in order to produce their fruits. Some notable examples of this are the navel orange, certain persimmons and seedless grapes.

At present in apples, pears, apricots, plums. cherries and the different berry fruits, the general policy is to give preference to commercial varieties which are self-fertile.

From the grower's standpoint the pollination problem may be summarized as follows :—

Select commercially popular varieties that may be grown in blocks without interfering with production.

If this is not possible, ensure that the general lay-out of the orchard permits effective cross-fertilization.

A good pollenizer should possess three main qualities—the pollen must be viable, it must be compatible in cross-fertilization with the variety it is intended to pollinate, and the two varieties should have blossoming periods that synchronize or overlap.

THE PAPAW OR PAPAYA*
(CARICA PAPAYA)

WITH frequent inquiries being made as to the method of propagation and with an increasing demand for this fruit in the metropolitan markets, it is felt the following notes will be of interest.

It is not the intention of the writer to convey to Gascoyne River settlers that the time is opportune for the establishing of any large commercial areas, but there are sufficient indications to warrant the consideration by settlers of the planting of a few " trees " as a profitable sideline to banana growing. Without entailing much additional time, water or other costs, they could be grown in such positions as along the irrigation drains, on the headlands, between the outside banana rows and the wind breaks, between the young fruit trees or in the pineapple beds. Prices in the past for this fruit have been encouraging despite the fact that little or no attention has been paid by settlers as regards type, quality or condition of fruit being sent to markets. True though it is that the demand is greater than the supply, considerable caution must be taken with the amount of supply owing to the peculiar nature of this and many other tropical fruits, a liking for which is an acquired taste.

The papaw or papaya (erroneously called paw paw by many of this State and which is an entirely different type of plant indigenous to Central U. S. A.) is a typical tropical plant and is a native of tropical America. It has proven itself quite suitable to Gascoyne conditions providing that normal care and attention are paid to cultural methods, and thrives best in a soil rich in organic matter possessing good drainage, in a sunny position free from frosts and boisterous winds.

THE PLANT

This is a fast growing herbaceous plant possessing usually an erect trunk attaining a height of 10 to 25 feet, which is fleshy and hollow. The leaves, which are large, sometimes 2 feet across, are dark green and are produced in clusters at the top of the plant on hollow, smooth stiff stalks. This growth is erect in the early stages of development but later as the leaf stalks grow, they bend outwards and then downwards, giving the plant a palm-like effect. The life of a leaf varies from 4–6 months and at the axils or union of the leaf stalk and trunk the flowers are produced.

THE FLOWERS—MALE AND FEMALE

The papaw is normally dioecious, *i.e.*, with the staminate or male and pistillate or female flowers produced on different plants. In addition to the

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* By G. B. Barnett, Tropical Adviser, Department of Agriculture in *Journal of the Department of Agriculture, Western Australia*, March, 1938.

staminate and pistillate forms, intermediate forms have been observed in which flowers of each sex occur in one plant. Staminate flowers may occur with rudimentary stigmas and ovaries which give rise to small worthless fruit and there is a hermaphrodite or bi-sexual type which regularly produces perfect flowers, is self-pollinated and yields excellent fruit. (While fruit of the staminate tree have been described as worthless there are instances of large and good-flavoured fruit having been produced but possessing thin skin and soft flesh which make them unfit for transport to market.) In the dioecious type the staminate or male plant the flowers are white, about an inch long and are borne in clusters on long pendent racemes sometimes 5 or 6 feet long, while the pistillate or female plant produces creamy yellow flowers about two inches long close to the trunk of the plant on short thick stalks from half an inch to two inches in length. Both types of flowers emit a very pleasant scent.

It appears that nature holds the determining of the papaw sex as a close secret for although many and varied are the suggestions that have been expounded concerning the determination of sex in the early stages of growth of the plant, the writer has yet to be convinced that any of the so-called "positive tests" are reliable except that the more vigorous plants in the nursery may possess a greater percentage of female plants. This line of selection is desirable apart from the view-point of sex, in that the most vigorous plants are the quickest to flower, thus maturing an early crop and such crop is usually borne low on the plant which facilitates harvesting.

THE FRUIT

The shape of the fruit varies from oblong to round, depending not only on type or variety. Soil, season, climate and cultural conditions seem to have considerable bearing on shape. The fruit when first developed are creamy white, but quickly take on a dark green colour. The weight varies from 1–10 lb. when mature. When ripe the skin is smooth, thin and usually of a yellow to deep orange colour, while some types are pale green and are not considered very favourably by the trade. The flesh is of firm butter texture and possesses a yellow to orange-yellow colour. In the centre of the fruit is a fairly large cavity where are carried numerous round or oblong-shaped black seeds. The thickness of the meat or flesh varies from half an inch to two inches.

METHODS OF PROPAGATION

The papaw may be propagated from cuttings, by grafts or seed, the latter being the commonest and to date most satisfactory method.

Cuttings are most successfully rooted when small limbs are removed from plants and care is taken to see that the natural swollen growth at the union of the small limb and parent plant is attached to the cutting.

Although this plant can be grafted successfully, there is little to be gained from this method of propagation for it has been observed that the parental qualities are not always retained except that the age of the parent seems to be transmitted in the scion. These facts appear to be present to the same degree in rooted cuttings.

SELECTION

As already mentioned the propagation by seed is the best method. Little attention has been paid in the past on the Gascoyne in the matter of selection, with the result that many worthless strains are in evidence which are not only unremunerative but are a menace to the better types growing in the same vicinity.

Seed should be selected from the fully ripe fruit and from a tree known to be of a healthy, robust, heavy-bearing nature. The fruit should possess a thick leathery highly coloured skin, a flesh of firm texture and good thickness. The shape, if possible, should be oblong, as this appears to be favoured by the trade, and a medium sized fruit is the most popular. Fruit with a very prominent nipple at the calyx end should be avoided as this tends to ripen earlier than the main body of the fruit and is subject to bruising, thus detracting from its value when presented to the buyer.

THE SEED BED

Seed may be raised either in beds or boxes which contain a good rich sandy loam. The seed should be planted soon after being removed from the ripe fruit but seed will retain a high percentage of germination for twelve months if washed after removal from the fruit and kept in an air tight jar in a cool place. The best time for raising seedlings is during the spring months—September–December. The seed should be planted in rows about 12 inches apart with 2–3 inches between seeds and covered with about half an inch of soil. The seedlings should be above ground in 2–3 weeks after planting in the spring. Thinning the seedlings out to 6–8 inches will encourage good sturdy growth. The soil should be kept only moist as excessive watering may cause damping off. If the seed beds are in sunny positions the seedlings should be ready for removal to their permanent positions in two months from planting of seed when the seedlings should be 6–8 inches high.

PLANTING OUT

Several hours prior to transplanting, the seed beds or boxes should receive a liberal watering, and planting out should be done in the cool of the day. After selecting the most robust and vigorous plants, every care should be taken to avoid destroying the roots or the drying out of roots during transplanting. A thorough watering is advisable as soon after planting as possible, and once the plants show signs of being established, weekly irrigation should be sufficient. If planting out large seedlings, it is advisable to remove the majority of the leaves several days prior to planting, leaving portion of the petiole or leaf stalk attached to the plant.

Owing to the impossibility of determining the sex of the seedlings prior to flowering, it is advisable to adopt close planting and planting in pairs about 18–24 inches apart, allowing 3–4 feet between pairs, is suggested. The thinning out of males, which usually predominate, should be done as soon as detected, and they should be cut up and dug into the soil as they are a valuable manure for the remaining plants. No definite advice can be given

as to how many males should be left as position of the plants has a considerable bearing on the matter, but as a guide 3 or 4 robust males should be satisfactory if well dispersed amongst 20 to 30 females.

While most plants have the tendency to develop the one upright stem, there are some that will develop lateral limbs early in life, which is very desirable as the plant then tends towards a low type growth carrying a larger crop of medium sized fruit low to the ground. To encourage the branching type habit, the growth may be nipped out when the plant is 3–5 feet high, but even this does not always force out the side vegetation. Some growers wait until the first main crop has set before removing the terminal growth when the branching habit can usually be obtained.

While plants may live for 10 or more years, it is usually found that after the second or third year the plant has produced its best commercial crops.

The plant readily responds to soil cultivation and liberal supplies of well-rotted organic matter, and will benefit from an application of Wyndham meat works manure, whenever manuring the bananas, bearing in mind that if the plant is kept producing vegetative growth, there will be a constant cropping of fruit.

HARVESTING AND HANDLING

Like most fruits the papaw attains its best flavour if allowed to remain on the plant until ripe, but this is not practicable if fruit is to arrive at Perth markets in good condition. The stage to harvest to metropolitan markets will vary with the season. During the winter months it is possible to allow the fruit to remain on the trees until a fair amount of colour is showing, but in the summer it is necessary to harvest as soon as the yellow colour commences to show on the fruit.

Harvesting should be done during the cool of the day by holding the fruit firmly and giving it a slight twist, when it should come away with portion of the fruit stalk attached. The fruit should be handled with the greatest of care as it is very easily bruised and marked; even the slightest marking at harvesting becomes very pronounced when the fruit is ripe. If possible, the fruit should be allowed to sweat in a cool place for about 12 hours prior to packing. The fruit may be packed in the standard tropical case (24¾ by 12 inches by 12 inches, inside measurement), or during times of high prices the ¾ flat is more desirable. A layer of wood wool, dry straw or crumpled paper should be placed in the bottom of the case, and each fruit should be liberally wrapped in paper before being placed in the case, making sure that a padding of the paper covers the stem end of the fruit. The fruit may be packed either erect or lengthwise along the case. Never place the fruit across the case, for after lidding the case always travels on its side and fruit so packed are liable to receive damage to the stem or calyx ends. When packed the fruit should be slightly lower than the side of the case, and a liberal layer of wood wool, or crumpled paper should be placed over the fruit before lidding. The use of dead banana leaves as padding material is not to be encouraged for it not only detracts from the "get up" of the

product but produces an unpleasant musty odour to the packed article. Use even grade fruit as far as possible, and upon the end of the case mention the count or number of fruit in the case.

USING THE FRUIT

The most popular method of using the fruit is by cutting halves or slices lengthwise, removing the seed and to suit the taste, sprinkling sugar, salt, pepper, orange or lemon juice over it. Served in this manner it is a very popular breakfast dish. Some people prefer a few of the seeds to be served with the fruit as they have a flavour similar to water cress and are claimed to possess great digestive properties. This fruit is becoming increasingly popular in cafes when served with ice cream. Cut in halves with the seed removed, and port wine added, it makes a delicious sweet for the menu.

Great medical properties are claimed for the fruit and plant from which is produced a milk-like fluid which when dried to a white powder contains " papain " and is used in the manufacturing of special digestive foods and chewing gum. The papain is harvested by making slight incisions in the skin of the fruit and the exuding fluid is collected in small vessels and then dried and ground to a powder. One authority claims that to extract 1½ lb. of papain approximately 1,500 average size fruit are required to be treated.

PESTS AND DISEASES

The plant is comparatively free from pests and diseases in Western Australia. Slight infestations of Red Spider have been recorded. The major loss of fruit appears to be from sun scald and slight fungus attack in the form of a rot which develops at the calyx end and exposed side of the fruit. The orange-piercing moth also does slight damage during drought periods.

REASONS FOR CROP FAILURES

Crop failure, or fruit developing towards maturity and then falling from the plant, may be the result of blossoms being attacked by insects or disease, or unfavourable soil or climatic conditions at fruit setting stage. Excessive watering or manuring at this stage can also cause trouble, but where these conditions do not prevail it is quite possible that pollination is at fault. The shrivelling and dropping of fruit from the male tree is common and, if an inspection is made of the interior of the fruit, it will be found that the seed is undeveloped. Infertile fruit is usually insipid in flavour and the flesh is thin and leathery.

PROPAGATION OF PLANTS—SEED VS. CUTTINGS

The Editor,
The Tropical Agriculturist,
Peradeniya.

Jaffna,
December 28, 1938.

SIR,

SOME years back I had an old rose plant, the flowers of which were of the ordinary pink colour. The plant produced berries, one of which I planted after it ripened on the plant to see whether it would germinate.

One of the seeds in the berry germinated and produced a rose plant, which grew up well.

It is well known that the ordinary method of propagating the rose plant is from cuttings. I do not know whether any others have been successful in growing the rose plant from seed. In this connexion I desire to know why it is that certain plants can generally be grown from seed only and certain other plants from cuttings only. Is it due to the differing structures of different plants, and if so what are they ?

I am, Sir,
Yours in service,
C. ARULAMBALAM.

(It is necessary to distinguish between plants that *can* be grown only from seed or cuttings and plants that *are generally* grown from seeds or cuttings.

In Nature, vegetative reproduction is almost as common as reproduction by seed, and although in the majority of species one process occurs much more frequently than the other, so that it becomes the normal method (and so that the other may even escape notice altogether except in special circumstances) yet there are comparatively few plants in which only one method is possible.

Under cultivation, two conditions are found—one in which reproduction is either by seed or cutting because it is more convenient, and the other in which domestication has been accompanied by sexual sterility. For example, the banana or plantain has no seeds because it has been selected for seedlessness, but wild species of *Musa* produce seeds in abundance ; the cultivated pineapple rarely contains a seed, but there are many races which do. Climatic effects are sometimes responsible for sterility, and plants transferred from temperate to tropical climates have become entirely vegetative probably because the absence of a cold season removes the stimulus to produce flowers. A change of environment may affect reproduction for other reasons ; for

example, the vanilla orchid does not set seed (unless artificially pollinated) outside its Central American home, because pollination is effected by a bee which occurs only in Central America.

On the other hand, many cultivated and ornamental plants are reproduced vegetatively because that is the only way to preserve their characters. The garden rose has been built up over many generations and it is estimated that not less than twenty-six species have contributed to its ancestry. A plant so hybrid in character cannot be expected to breed true from seed, and reproduction by cutting is essential if Dorothy Perkins or Marechal Neil are to retain their identity. Mangoes and grapefruit can be grown from seed, but the results will be disappointing for similar reasons. Both have been selected from a mixed lot of material, and to grow them from seed would be to allow them to degenerate. Rubber must be reproduced by grafting if a uniform population is to be obtained, and some method of vegetative reproduction will become necessary if uniformity is ever required on tea estates.—Ed., T. A.)

THE IMPERIAL BUREAU OF DAIRY SCIENCE

Imperial Bureau of Dairy Science,
Shinfield, Nr. Reading,
England,
12th December, 1938.

The Editor,
The Tropical Agriculturist,
Department of Agriculture,
Peradeniya,
Ceylon.

DEAR SIR,

I enclose a brief description of the nature and functions of the new Imperial Bureau of Dairy Science. Some months ago, a certain amount of more or less unreliable information about the Bureau appeared in the Press. Now that the Bureau has been established you may be interested to have this authoritative information. I would be much obliged if you could publish it.

Yours faithfully,
W. G. SUTTON,
Deputy Director.

In 1936 the British Commonwealth Scientific Conference which met in London to consider the working of the organizations controlled by the Executive Council of the Imperial Agricultural Bureaux, recommended that a new Imperial Bureau of Dairy Science be established. The conference also suggested the National Institute for Research in Dairying as the most suitable location for the Bureau.

Following agreement by all the authorities concerned the new Imperial Bureau of Dairy Science has now been established at Shinfield, near Reading. Prof. H. D. Kay, O.B.E., Ph.D., D.Sc., Director of the National Institute for Research in Dairying, has been appointed Director of the Bureau. Mr. W. G. Sutton, M.Sc., A.I.C., from Massey, Agricultural College, New Zealand, has been appointed Deputy Director and has now taken up his duties. The Bureau is financed co-operatively by the Governments of the British Empire in the same way as the other Imperial Agricultural Bureaux.

The functions of the Bureau are to index research work in dairy science, whether carried out in the Empire or elsewhere ; to collect, abstract and collate information bearing on dairy science and to distribute such information both by publication and by private communication to research workers, officials, and advisory officers throughout the Empire. In addition the Bureau is charged with the duty of establishing and maintaining contact between research workers with common interests, promoting conferences of workers and visits to research centres, and in general encouraging the circulation of information ideas, material and personnel.

The field of dairy science to be covered by the Bureau was defined by the Conference when recommending its establishment. This field includes the microbiology, chemistry, and physics of milk and its products ; animal diseases in so far as they affect milk and its products ; the technology of processing milk and manufacturing dairy products ; the physiology of milk secretion as affecting quality and quantity of milk and dairy products ; standards for the composition and quality of milk and its products.

The routine duties of the Bureau, such as indexing and abstracting, will already be familiar to many dairy workers from the activities of the Bureaux already established in other subjects. An aspect of Bureau work which may not be so well known and understood is the more informal service which can be given to research workers, teachers, and field officers. The Bureau aims to be the friend of these dairy workers. The Bureau will deal directly with the individual workers in dairy science, who are invited to write to the Bureau for information which is not obtainable in their own countries. The Bureau may be able to supply the information itself, or to put the inquirer in touch with someone who can do so more effectively.

The new Imperial Bureau of Dairy Science has been established in answer to requests for a clearing house for information in dairy science ; its value to dairy science, and to the dairy industry generally will largely depend on the extent to which research workers and others avail themselves of its services.

REPORT OF THE PROCEEDINGS OF THE FOURTH MEETING OF THE CENTRAL BOARD OF AGRICULTURE

THE fourth meeting of the Central Board of Agriculture was held at Peradeniya in the Board Room of the Department of Agriculture at 2.30 P.M. on Thursday, November 17, 1938.

His Excellency the Governor presided and the following members were present :—Mr. E. Rodrigo, C.C.S., (Acting Director of Agriculture and Chairman of the Board), Messrs. S. F. Amerasinghe (Sr.), S. Armstrong, C. Arulambalam, A. C. Attygalle, J. P. Blackmore, P. B. Bulankulama, Dissawe, A. Canagasingham, Dr. Reginald Child (Director, Coconut Research Scheme of Ceylon), Messrs. V. Coomaraswamy (Acting Conservator of Forests), R. G. Coombe, M. Crawford (Deputy Director, Animal Husbandry and Government Veterinary Surgeon), E. C. de Fonseka (Jr.), C. N. E. J. de Mel (Principal Farm School), G. de Zoysa (Acting Registrar of Co-operative Societies), George E. de Silva, M.S.C., Bertram de Zilva, S. L. Bandara-Dharmakirti, R.M., M. M. Ebrahim, James Forbes (Jr.), R. P. Gaddum, M.S.C., Bruce S. Gibbon, Dr. J. C. Haigh (Botanist), Messrs. A. K. J. Henderson *vice* the Commissioner for the Development of Agricultural Marketing, L. L. Hunter, Dr. J. C. Hutson (Entomologist), Dr. A. W. R. Joachim (Chemist), Messrs. W. C. Lester-Smith (Agricultural Officer, Plant Pests and Soil Conservation), S. M. K. B. Madukande, Dissawe, W. A. Muttukumaru, Mudaliyar S. Muttutamby, Dr. R. V. Norris (Director, Tea Research Institute of Ceylon), Messrs. T. E. H. O'Brien (Director, Rubber Research Scheme of Ceylon), W. R. C. Paul (Acting Plant Pathologist), Wilmot A. Perera, F. A. E. Price, Marcus S. Rockwood, R. C. Scott (Chairman, Planters' Association of Ceylon), B. M. Selwyn, Rolf Smerdon, R. H. Spencer Schrader, A. T. Sydney Smith, J. Tyagaraja (Chairman, Low Country Products Association), U. B. Unamboowe, Mudaliyar N. Wickramaratne, Messrs. A. A. Wickremasinghe, C. L. Wickremesinghe (Commissioner of Lands), Rev. Father L. W. Wickremasinghe, Messrs. C. Huntley Wilkinson, J. H. Wilson (Acting Director of Irrigation), Col. T. Y. Wright and Mr. M. Park, Secretary.

The following visitors were also present :—The Honourable Mr. D. S. Senanayake (Minister for Agriculture and Lands), Messrs. R. Aluwihare, C. M. W. Davies, Dr. T. Eden, Messrs. E. J. Livera, T. M. Z. Mahamooth, W. Molegode, Dr. A. Nell, Messrs. H. A. Pieris, Gordon Pyper, C. Roberts, L. A. Whelan, G. V. Wickramasekera and S. P. Wickremesinghe.

The following members intimated their inability to attend the meeting :— Mr. G. C. Rambukpota, M.S.C. and Mr. T. H. E. Moonemalle.

CONFIRMATION OF MINUTES

The draft minutes of the third meeting of the Board held on July 14, 1938, which had been printed and circulated among the members were confirmed.

ACTION TAKEN ON THE DECISIONS OF THE THIRD MEETING OF THE CENTRAL BOARD OF AGRICULTURE

The President asked the Chairman to make a statement regarding the action taken on the decisions made at the third meeting of the Board.

Before asking the permission of the Board for the Secretary to read the statement, the Chairman (Mr. E. Rodrigo, Acting Director of Agriculture) expressed the pleasure and pride of the Board in the presence of His Excellency the Governor. The Chairman said that His Excellency's presence was a source of inspiration for which the Board was very grateful. The Secretary then read a statement of the action taken on the decisions of the Board at its third meeting.

RESCISSION OF THE RESOLUTIONS ON OIDIUM LEAF DISEASE

Mr. R. G. Coombe reviewed what had transpired since proposals regarding the appointment of District Oidium Committees and the introduction of compulsory dusting for the control of Oidium were passed at the first meeting of the Board. He stated that a conference called by the Planters' Association of Ceylon had supported a resolution passed by the Rubber Research Board to the effect that, while sulphur dusting was beneficial for the control of Oidium disease, it was felt that the imposition of control measures was neither practical nor desirable at the present time nor was it desirable to ask District Agricultural Committees to appoint Oidium Sub-Committees. In view of that resolution, Mr. R. G. Coombe proposed the rescission of the two motions on this subject passed at the first meeting of the Board.

In seconding the proposal Mr. Rolf Smerdon urged the necessity of further work on the control of Oidium disease. Mr. O'Brien, Director, Rubber Research Scheme, supported the proposal and stated that the Rubber Research Board had approved a further programme of research on Oidium disease and its control.

The Board unanimously approved of the rescission of the two motions.

THE RELEASE OF LAND FOR THE GROWTH OF FOOD CROPS IN THE VICINITY OF ESTATES

Mr. R. G. Coombe moved the following resolutions standing in his name:—

" (a) That with a view to supplementing the supply of food for labourers on estates in the event of food control being enforced, Government be requested to lease land—forest and stream reserves excepted—suitable for the growth of all kinds of indigenous vegetables where available in the vicinity of estates.

(b) That should the Department of Agriculture not be able to stock seed for sale, as it used to, of all kinds of indigenous vegetables, the Food Controller be requested to make the necessary arrangements to ensure supplies of these seeds being available when required."

In introducing his motions, Mr. Coombe stated that with the increased employment of indigenous labour on estates there was a growing demand for land in the vicinity of estates to enable them to grow vegetables and other food crops. He felt that, if Crown land in the vicinity of estates could be made available, it would be an added inducement for indigenous labour to stay on estates. He suggested that plots of land not more than 10 acres in extent should be leased out to labourers.

With regard to the second part of his motion, he said that, if it were not possible for the Department of Agriculture to stock seed and planting material for sale, these should be made available as and when required through the Food Control Department.

Col. T. Y. Wright seconded the motion.

Mr. C. L. Wickremesinghe, Land Commissioner, said that it would be necessary to comply with certain statutory requirements before Crown land could be leased. He stated further that it would be necessary to ensure that land so leased would be used only for the production of foodstuffs. He suggested the appointment of a committee to go into the question. Mr. G. E. de Silva and Mudaliyar N. Wickramaratne supported the motion but suggested that Crown land should also be leased to villagers.

The Honourable Mr. D. S. Senanayake, Minister for Agriculture and Lands, welcomed the proposal but suggested that in view of the shortage of land available, estates should consider setting aside part of their area for the growing of food crops.

He stated briefly the policy in regard to the production and sale of seed and pointed out that it would be possible for members of the public to purchase tested seed of high quality from the new departmental seed stations.

Further discussion followed and the following amendment was proposed and approved by the Board :—

> " That, with a view to supplementing the supply of food for labourers on estates in the event of food control being enforced, Government be requested to lease land—forest and stream reserves being excepted—suitable for the growth of all kinds of indigenous foodstuffs, including vegetables, where available in the vicinity of estates."

Mr. C. L. Wickremesinghe proposed and Mr. F. A. E. Price seconded that the resolution be referred to the Executive Committee of the Central Board of Agriculture for consideration and report. This was approved by the Board.

PLOUGH CATTLE FOR THE REQUIREMENTS OF PADDY CULTIVATION

Mr. M. Crawford, Deputy Director (Animal Husbandry) and Government Veterinary Surgeon, presented the report of the Advisory Committee on Animal Husbandry on the following motion of Mudaliyar N. Wickramaratne, which had been referred to it for its consideration and report to the Board :—

> "That the Department of Agriculture should take steps to make a census of the plough cattle in the Island with a view to determining the requirements of paddy cultivation in each area in this respect and initiating a scheme for ensuring a sufficient supply of plough cattle for each area."

The conclusions of the Advisory Committee were :—

(a) That it was not practicable for the staff of the Agricultural Department to undertake a census of plough cattle.

(b) A scheme to insure plough cattle was impracticable as they knew of no insurance company which would undertake the risk and further that they considered an insurance scheme would not be likely to encourage cultivators to take greater care of their cattle but was more likely to have the contrary effect.

(c) That they considered it was necessary to devise some means whereby cultivators in need of cattle may be informed of places where such cattle may be obtained and encouraged to go to such places to obtain their requirements. The Committee suggested that this might be done by circularizing all Revenue Officers, arranging cattle fairs in areas where there is a surplus of cattle, advertising such fairs in areas where a shortage exists, endeavouring to get cheap rail fares for cultivators travelling to the fairs, and if necessary inducing the railway to run special cattle trains in connection with the fairs.

Mr. C. Huntley Wilkinson moved that the report be adopted, and that the Advisory Committee on Animal Husbandry be asked to devise a scheme in terms of recommendation (c) above.

Mudaliyar Wickramaratne expressed disappointment at the report. He felt that a scheme of co-operative insurance of cattle was both feasible and desirable and that the taking of a census of cattle was not impracticable.

Further discussion followed in which several speakers agreed that insurance of cattle other than through co-operative societies was impracticable. Finally, at the suggestion of the President, Mr. Huntley Wilkinson moved as an amendment to Mudaliyar Wickramaratne's original proposal—

"That the Director of Agriculture should consider the requirements of paddy cultivation in each area and initiate a scheme for ensuring a sufficient supply of cattle in each area."

The amendment was accepted by Mudaliyar Wickramaratne, was put to the meeting and carried.

ALL-CEYLON CATTLE SHOW

Mr. M. Crawford, Deputy Director (Animal Husbandry) and Government Veterinary Surgeon, in introducing this subject stated that at the first meeting of the present Board the following resolution, proposed by Major E. C. de Fonseka, had been held over in view of the proposal to form a Cattle Breeders' Association under the auspices of which a cattle show might well be held :—

" That an All-Island Cattle Show should be held in Colombo at an early date under the auspices of the Central Board of Agriculture."

Mr. M. Crawford then stated that the Cattle Breeders' Association had been duly formed. The object of the association was the promotion of the breeding of improved types of cattle by :—

(a) Holding or supporting Cattle Shows.

(b) Fixing standards for Ceylon breeds of cattle.

(c) Establishing and maintaining a herd book or books.

(d) The dissemination of information.

(e) Generally advancing or protecting the interest of cattle breeders.

Arrangements were well in hand for holding an All-Ceylon Cattle Show in Colombo on March 10 and 11, 1939. The show would be held on the Race Course, Colombo, by courtesy of the Ceylon Turf Club.

Mr. Crawford's report was received with acclamation and, in the circumstances, Major E. C. de Fonseka's original proposal was withdrawn.

FORMULATION OF A SCHEME OF FARMING AS A CAREER FOR EDUCATED YOUNG MEN

Mudaliyar N. Wickramaratne moved :—

" In view of the restrictions now placed on the extension of the tea and rubber planting industries, the absence of satisfactory prospects in the coconut planting industry and the general overcrowding of the learned professions in the Island it is the opinion of this Board that the Department of Agriculture should formulate and publish a scheme, or schemes, of farming as a career, for the information of the many young men who pass from our schools each year."

Speaking to his motion, Mudaliyar N. Wickramaratne said that large numbers of young men found themselves without careers when they left school. Land was available for development. A scheme was necessary whereby young men could undertake farming as a career.

Mr. C. Arulambalam seconded the motion.

Mr. E. Rodrigo, Acting Director of Agriculture, said that he and the Department of Agriculture were in entire sympathy with the motion. He felt however that the Board should take steps to implement a resolution of this type and suggested that it be referred to the Executive Committee of the Board for report. The Hon'ble Mr. D. S. Senanayake, Minister for Agriculture and Lands, felt that the Board should assist Government by preparing a scheme.

After further discussion, the President proposed as an amendment that the Director of Agriculture's suggestion that the matter be referred to the Executive Committee of the Central Board of Agriculture for the formulation of a scheme be adopted. Mudaliyar Wickramaratne agreed to the amendment which was put to the meeting and carried unanimously.

ALL-CEYLON AGRICULTURAL SHOWS

Col. T. Y. Wright stated that a memorandum on the value to agriculture of large agricultural shows had been circulated to all members of the Board. He felt that that question was one of some importance to Ceylon and proposed that the following sub-committee be appointed to go into the matter, to consider questions of finance, control and the best time of the year for the holding of the shows and to submit a report :—

Sir Wilfred de Soysa, Messrs. U. B. Unamboowe, Wilmot A. Perera, Mudaliyar N. Wickramaratne, Mr. S. Armstrong, Major E. C. de Fonseka,

and the Commissioner for Development of Agricultural Marketing with the Agricultural Officer (Propaganda) co-opted to the committee.

Mr. F. A. E. Price seconded the motion.

Mr. R. G. Coombe felt that, if such shows were held, at least fifty per cent. of the prizes should be restricted to villagers only. Mr. Rolf Smerdon suggested that these be restricted not to villagers but to cultivators only.

The proposal was put to the meeting and carried unanimously.

FOOD PRODUCTION

Mudaliyar N. Wickramaratne moved :—

"That this Board considers that the Department of Agriculture should pursue a more vigorous and effective policy of production of food crops in this country."

In introducing his motion, Mudaliyar Wickramaratne stated that he understood that the Director of Agriculture had recently submitted to the Honourable the Minister for Agriculture and Lands a memorandum containing suggestions for increasing food production in Ceylon. In the circumstances he wished only to raise one or two points. He felt that the production of rice in Ceylon should be increased rather by raising the productivity of existing paddy land than by the opening up of new land. To this end he suggested that the Vel-Vidanes should be placed under control of Agricultural Instructors who would be allotted ranges with the definite object of increasing paddy production.

The President pointed out that, as it was worded, the proposal was an indictment of the Department of Agriculture.

Mr. Tyagaraja in seconding the motion, said that he wished it to be regarded as a proposal to speed up food production.

Mr. Armstrong supported the motion.

The Honourable Mr. D. S. Senanayake stated that, if high yields of paddy were to be maintained, it was necessary to introduce a scheme of rotation and that, in consequence, it would be necessary to increase the area under cultivation. He touched on the difficulties of obtaining remunerative returns from paddy cultivation and indicated the steps which were being taken by Government to overcome these difficulties by providing land, seed, water, and rice mills and by educating the growers in improved methods of cultivation.

A general discussion followed.

On the suggestion of His Excellency the Governor, Mudaliyar Wickramaratne agreed to amend his resolution. The following amended resolution was put to the meeting and carried :—

"That this Board considers that the Department of Agriculture should pursue a more and more vigorous and effective policy of production of food crops in this country."

At this stage His Excellency the Governor asked the permission of the Board to take the item on composting next and also to allow Dr. Eden of the Tea Research Institute, who was not a member of the Board, to lead the discussion. The Board approved.

COMPOSTING

Dr. T. Eden stated that on November 8, 1934, the Central Board of Agriculture discussed at some length the question of compost manufacture. At the conclusion of the discussions, the Board decided to review the question from time to time.

While all were agreed that compost was an extremely valuable form of fertilizer, there had been a great deal of controversy since the matter was first discussed by the Board, the controversy raging largely on the question whether green material grown on land should be removed for making into compost which would subsequently be incorporated in the soil or whether it was more economic and valuable to incorporate green material into the soil *in situ* and, secondly, on the relative merits of compost manure and artificial fertilizers, with or without the direct addition of green material.

Dr. Eden stated that current practice seemed to have moved away from the extreme position that was held by many, a year or so ago. It was now generally agreed that it was not economic to make compost out of "internal" material and that the use of artificial manure as a supplement to green manuring or compost manuring was desirable.

Continuing, he stated that there was room for more composting on small-holdings and suggested that more use should be made of paddy straw which was often wasted or burned.

Dr. Eden touched on other points about which there had been some discussion, including the importance of mycorrhizas and the effect of compost on their development, the use of lime and potash in composting, the value of chemical analysis of compost manures, the claim that the use of compost manures imposes on the plants resistance to diseases and pests and, finally, modifications in the process of manufacture of compost to ensure more even aeration of the heaps.

Mr. C. Huntley Wilkinson was of opinion that the question of composting had attained its true perspective. All were agreed that it was most useful as additional to other nutrients. He felt that tea would always benefit from compost made from green stuff grown on land other than that on which the tea was growing.

Mr. Marcus Rockwood asked that more publicity should be given to methods of composting and the materials that could be used.

Mr. Rodrigo said that the Department of Agriculture had issued leaflets describing the manner of making compost. He said that steps would be taken to prepare fuller information.

THE CONTROL OF PADDY CULTIVATION IN RAIN-FED LANDS IN THE EASTERN PROVINCE

With the permission of the Board the next item to be discussed was the proposal of Mr. S. Armstrong :

"This Board strongly recommends to the Honourable the Minister for Agriculture and Lands that early steps be taken to frame rules under section 29 (31) of the Village Communities Ordinance, No. 9 of 1924, to control paddy cultivation in rain-fed lands as well as those irrigated by village tanks

in the Eastern Province in view of the recent ruling of the Attorney-General with regard to the invalidity of the rules under the Irrigation Ordinance in force up to 1934 which has resulted in neglecting *manavari* or *maha* cultivation in the Eastern Province."

In introducing the motion, Mr. Armstrong stated that, in the Batticaloa District, the cultivation of paddy fields irrigated by tanks or by means of dams across streams and elas, not included in major irrigation works, and the cultivation, known as *manavari* or *maha* cultivation, of rain-fed paddy lands were originally controlled by a Proclamation dated October 18, 1872, and the Paddy Cultivation Ordinance, No. 23 of 1889. More recently, the cultivation of these lands had been controlled by the Government Agent under Section 11 of the Irrigation Ordinance, No. 45 of 1917. In 1934, the Attorney-General ruled that rain-fed *manavari* lands and the lands controlled by village tanks, and dammed streams and elas were outside the jurisdiction of "Irrigation Districts" as proclaimed under the Irrigation Ordinance, No. 45 of 1917. In consequence, the rules relating to the control of paddy cultivation in these areas had relaxed with the result that large areas of paddy lands in the Batticaloa and Trincomalee Districts were now neglected.

Mr. Armstrong stated that he had been asked by the District Agricultural Committee, Batticaloa, and by a recently held conference of Chairmen of Village Committees of Batticaloa District to press for the framing of rules under Section 29 (31) of the Village Communities Ordinance, No. 9 of 1924. He understood that cultivation under village tanks in the North-Western Province was controlled under Village Committee rules and felt that there should be no difficulty in framing rules for the Eastern Province under that Ordinance.

On the Hon'ble the Minister for Agriculture and Lands giving an assurance that attention would be given to rules drafted by Village Committees as soon as they were received, Mr. Armstrong withdrew his motion and expressed his thanks to the Minister.

TOBACCO OFFICER

Mr. C. Arulambalam asked what was the present position in regard to the appointment of a Tobacco Officer. The Hon'ble Mr. D. S. Senanayake stated in reply that he had received a cablegram from the Secretary of State for the Colonies saying that the Tobacco Officer had been appointed. He would therefore arrive in Ceylon shortly.

The meeting terminated at 5.35 P.M.

MALCOLM PARK,
Secretary, Central Board of Agriculture.

Peradeniya, December 9, 1938.

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ANIMAL DISEASE RETURN FOR THE MONTH ENDED JANUARY 31, 1939

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1939	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Foot-and-mouth disease	..	..	..	..	..	..
	Piroplasmosis	..	..	..	..	..	..
	Blackquarter	1	1	1	..	..	..
	Rabies	1	1	..	..	..	1
Colombo Municipality	Foot-and-mouth disease	..	..	..	..	..	..
	Anthrax	..	..	..	..	..	..
	Rabies	..	..	..	..	..	..
	Piroplasmosis	..	..	..	..	..	..
Cattle Quarantine Station	Foot-and-mouth disease	..	..	..	..	..	..
	Anthrax	4	4	4	..	..	..
Central	Foot-and-mouth disease	..	..	..	..	..	..
	Anthrax	..	..	..	..	..	..
	Piroplasmosis	..	..	..	..	..	..
	Blackquarter	..	..	..	..	..	..
	Rabies	2	2	..	..	..	2
Southern	Foot-and-mouth disease	..	..	..	..	..	..
	Rabies	..	..	..	..	..	..
Northern	Foot-and-mouth disease	69	69	4	65	..	..
	Rabies	..	..	..	..	..	..
Eastern	Foot-and-mouth disease	..	..	..	..	..	..
North-Western	Foot-and-mouth disease	..	..	..	..	..	..
	Goat Pox	..	..	..	..	..	..
	Haemorrhagic Septicaemia	..	..	..	..	..	..
	Piroplasmosis	..	..	..	..	..	..
	Contagious mange	..	..	..	..	..	..
	Rabies	1	1	..	..	..	1
North-Central	Foot-and-mouth disease	1,037	385	..	658	379	..
	Blackquarter	..	..	..	..	..	..
	Haemorrhagic Septicaemia	..	..	..	..	..	..
Uva	Foot-and-mouth disease	..	..	..	..	..	..
	Rabies	..	..	..	..	..	..
	Blackquarter	..	..	..	..	..	..
Sabaragamuwa	Foot-and-mouth disease	..	..	..	..	..	..
	Haemorrhagic Septicaemia	1	1	1	..	..	..

Department of Agriculture,
Peradeniya, February 15, 1939.

T. M. Z. MAHAMOOTH,
for Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, JANUARY, 1939

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	84·9	—1·3	71·1	—1·0	70	90	5·4	6·61	12	+ 2·58
Puttalam ..	84·5	—0·8	69·1	—1·1	74	93	6·0	3·27	8	— 0·31
Mannar ..	82·3	—1·5	74·0	—0·3	75	86	6·0	4·08	9	+ 0·12
Jaffna ..	81·6	—1·3	71·7	—0·6	72	88	5·9	5·78	9	+ 1·44
Trincomalee ..	79·1	—1·5	74·8	—0·4	82	84	5·8	6·98	10	— 1·72
Batticaloa ..	80·2	—1·3	73·1	—0·6	80	88	6·3	3·98	10	— 9·79
Hambantota ..	85·6	+0·9	72·0	—0·7	70	85	5·0	0·31	6	— 3·39
Galle ..	82·7	—1·3	72·4	—0·4	77	90	5·5	2·34	9	— 1·30
Ratnapura ..	87·6	—1·4	70·2	—1·0	70	93	5·7	4·82	13	— 1·65
Anuradhapura ..	82·4	—0·3	67·4	—2·0	77	95	6·2	6·40	9	+ 0·69
Kurunegala ..	85·9	—0·2	69·5	—0·4	68	90	6·8	6·74	10	+ 1·87
Kandy ..	83·1	+0·4	66·2	—1·3	68	89	4·8	6·09	5	— 0·57
Badulla ..	76·2	+0·1	63·1	—0·7	80	94	5·8	4·44	13	— 6·11
Diyatalawa ..	72·6	+1·0	56·7	—1·0	76	94	6·4	2·59	12	— 3·75
Hakgala ..	67·4	+1·5	52·2	—0·1	80	91	6·8	6·75	13	— 5·38
Nuwara Eliya ..	67·7	+ 0·3	46·7	—0·5	70	93	6·8	4·05	13	— 2·69

The rainfall for January was below normal over the greater part of the Island, appreciable excess being mainly confined to the west of the main hill-country. The largest deficits were 23·02 inches at Upper St. Martin's, 20·66 inches at Hendon, 18·54 inches at Lower St. Martin's, and 15·04 inches at Ledgerwatte, all stations on the eastern or north-eastern slopes of the hills, while deficits of 10–15 inches were commonly reported between the hill country and the eastern coast. The greatest excess was 6·31 inches at Marambekanda, while two other stations, Gookiyanakanda and Kenilworth, also reported excesses of over 5 inches.

The highest monthly totals were 21·68 inches at Dooroomadella and 20·70 inches at Hendon, while 6 other stations, St. Martin's Upper and Lower, Sacumbe, Illukkumbura, Korahena, and Gammaduwa, all on the eastern or north-eastern slopes of the hills, recorded over 15 inches for the month. Labugama with 7·36 was 0·45 of an inch above average. In the extreme south and in the south-east of the Island, under 2 inches were recorded for the month, several stations recording less than half an inch. No stations, however, reported no rain at all.

There were 13 daily falls of 5 inches or over during the month, the highest being 9·14 inches on the 31st, at Maduwanwela. The majority of these heavy falls occurred on the 18th.

During the first few days of the month very dry conditions prevailed, with moderately steep northerly pressure gradients and very low night temperatures. Under the influence of a depression that formed in the Bay of Bengal to the east of the Island on the 8th, and passed over the Island about the 11th, the weather became unsettled, and fairly heavy widespread rain occurred between the 9th and the 11th. Although conditions improved somewhat thereafter, a fair amount of rain was experienced up to the 20th, which in the south-west of the Island was generally due to thunderstorm activity. Except for the 24th and 25th, when fairly widespread rain occurred again, dry settled weather prevailed during the last third of the month.

Temperatures and humidity were on the whole below normal. Cloud amounts were generally slightly in excess. Barometric pressure was about normal, while winds were above average strength, the wind direction being generally N.E. or N.N.E.

H. JAMESON,
Superintendent, Observatory.

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EDITORIAL

THE INSECT INFESTATION OF CACAO BEANS

THE infestation by insects of cacao beans while in store at certain wharves and docks in London has been regarded as a problem of importance for many years. Although several insects are concerned, the most important are moths of the genus *Ephestia*. Apart from the actual loss of the stored product directly due to insect attack, the transference of infested beans from the warehouses to chocolate factories leads to the liberation of moths in the latter buildings with the resultant danger of infestation of manufactured chocolates and cocoa. Furthermore, as *Ephestia* moths do not confine their attacks to cacao, the presence of stocks of infested cacao beans in warehouses in which are stored certain other products liable to attack by the same insects constitutes a source of contamination of these products which causes those concerned a good deal of anxiety.

The problem is a three-fold one—infestation in the exporting country, in the London warehouses and in the cocoa and chocolate factories in various parts of England. The solution of the second and third aspects of this problem would present no serious difficulty if the first did not arise, and it was for this reason that an investigation was decided upon by the trades concerned with the primary object of determining the precise source of infestation in exporting countries. The principal countries exporting cacao to England were invited to collaborate in this inquiry and the results of Ceylon's participation in the investigation are given in this number of our journal.

Of the 34,000 acres under cacao in Ceylon, approximately 70 per cent. are controlled by small-holders, the balance consisting of large European-owned estates and a few small estates owned by Indian Tamils. The course followed by the cured cacao of these two main classes of producer, from the up-country drying floor to the exporting vessel in Colombo, is not the same and, consequently, it was necessary for the inquiry to proceed

along two lines, one to trace the produce of the small-holder and the other that of the estates. The method of periodical sampling in each case is described in Dr. Fernando's article.

One interesting fact which has been disclosed in the course of the local inquiry is that the general belief that initial infestation of cacao beans by *Ephestia* in exporting countries takes place on the cacao drying-floor, is not substantiated under the conditions which prevail in Ceylon. It has been shown, however, that infestation may occur in this country during storage at all subsequent stages up to the time of shipment, both in the case of the product of well-managed estates as well as of that of the peasant-producer. For this reason, it is very necessary that all periods of storage should be curtailed to the lowest minimum possible and that the transit of the cured beans between producer and shipper should be accelerated. The prevalent practice of holding stocks in the hope of a market rise cannot be applied to this product if insect infestation is to be avoided or reduced. The investigation has demonstrated the liability to attack of cracked and broken beans, thus indicating increased care in curing to eliminate this source of attraction to the ovipositing moths. Finally, attention to places of storage will further reduce the risk of infestation. Wooden floors permit of an accumulation of cacao fragments in the spaces between planks and thus afford media in which the moths can develop. Where possible, such floors should be replaced by well-laid cement. In any case, frequent sweeping is essential and walls and ceilings should be whitewashed at regular intervals. Good lighting and ventilation are also required.

Although this world-wide investigation has been initiated by the manufacturers in England concerned, for their own purposes, it is very desirable that exporting countries should profit by the information which has been gained in the course of the inquiry. It is hoped that those in Ceylon who are associated with the cacao trade, whether they be growers, dealers, brokers or shippers, will give serious consideration to Dr. Fernando's article which describes an inquiry of considerable local importance and one which has been conducted in a particularly complete and efficient manner.

THE SOURCES OF EPHESTIA INFESTATION OF STORED CACAO IN CEYLON

M. FERNANDO, Ph.D., B.Sc., D.I.C.,
RESEARCH PROBATIONER IN PLANT PATHOLOGY

As far back as 1921, Knapp made mention of the tendency of Ceylon cacao to be " slightly grubby ". The percentage of insect-damaged beans in Ceylon exports at the time was in the neighbourhood of 2·0 per cent. ; the average for the world's production was 1·6 per cent. The question of insect infestation assumed unpleasant prominence in 1934, when Ceylon's largest individual customer, the Philippine Islands, insisted on the fumigation against insect damage of all cacao imports from Ceylon.

The insects associated with the spoilage of stored cacao in Ceylon include the cacao moth (*Ephestia elutella* Hb.), the fig moth (*Ephestia cautella* Walk.), the rice moth (*Corcyra cephalonica* Staint.) and the Tephrosia beetle (*Araecerus fasciculatus* DeG.). In an examination by Munro and Thomson (1929) of 143 bags of Ceylon cacao received at the Port of London, 49 bags were observed to be infested with *E. elutella*, six with *C. cephalonica* and four (three doubtful) with *A. fasciculatus*. That species of *Ephestia* constitute the major pests of Ceylon cacao and, for that matter, of cacao from most parts of the world, is now generally appreciated.

Hutson (1932) estimates the duration under tropical conditions of the incubation period of the egg, the larval period, the pupal period and the total life-cycle of *E. elutella* at five to nine days, eight to ten weeks, nine to twelve days and ten to thirteen weeks, respectively. In cacao spoilage, it is of course the larval phase that is of especial interest. The *Ephestia* larva is unable to penetrate the hard shell of a fermented cacao bean and can invade only cracked and broken beans. The larva of *Araecerus*, on the other hand, is able to rupture the cacao shell and may accordingly prove an important accessory to *Ephestia* invasion. The *Ephestia* larva consumes the cotyledon substance of the bean, replacing it with characteristic frass, *viz.*, large fæcal pellets held together by fine webbing. Apart from cacao, the larva can subsist on an extremely varied diet, ranging from dried vegetables, tobacco, various kinds of seeds and cereals to the dead bodies of its own parents. These polyphagous habits make *Ephestia* control extremely difficult.

In 1936, the British Association of Research for the Cocoa, Chocolate, Sugar Confectionery and Jam Trades, London, in collaboration with the Department of Agriculture, Ceylon, initiated an investigation into the sources of *Ephestia* infestation of stored cacao in Ceylon, as an essential preliminary to the application of control measures. A description of the methods employed in that investigation and the results obtained are presented below.

EXPERIMENTAL MATERIAL AND METHODS

Ceylon has an acreage of approximately 34,000 under cacao (*The Ceylon Blue Book*, 1936). Nearly the whole of this area is in the Kandy, Dumbara and the Matale Districts. The trees are Forastero-Criollo hybrids. Ceylon cacao had, at one time, a large admixture of Criollo in its composition. Recent years have seen a gradual replacement of the Criollo strains by predominantly Forastero types. The main or autumn crop is ready for picking during the period November–January. A small spring crop is available in May, June and July.

Cacao plantations in Ceylon fall into two rather well-defined classes; the large European-owned estates—a single estate of this type may cover as much as 2,700 acres—and the peasants' small-holdings averaging one to three acres each. A few estates owned by Indian Tamils constitute a class intermediate in type and extent. The small-holdings contribute nearly 70 per cent. of Ceylon's total output of cacao, and are accordingly of especial interest in the present connexion. The pre-fermentation history of small-holders' cacao has been described by Fernando (1938). The small-holder sells his cured cacao to a local petty dealer in quantities ranging from about 3 lb. to 30 lb. To carry the process of curing to completion ten to fifteen days may be necessary. Many villagers, however, sell their cacao after partially drying it for two to three days; the drying is completed by the dealer. The local dealer's collections are allowed to pile up till their proportions warrant sale to a larger dealer. Small-holders' cacao passes through a relay of dealers of progressively increasing importance—nearly all of them Moors—till it eventually reaches a trader in the Pettah, Colombo. In the course of these successive transfers, the cacao is subjected to a considerable amount of bulking and grading, and to attempts at improving the complexion of the shell with annatto or brick-dust. Furthermore, this cacao remains in storage at each dealer's warehouse for periods varying from a few days to several weeks. When favourable market conditions obtain, the Pettah dealer sells his cacao to one of the large firms of European exporters. The cacao undergoes an elaborate process of regrading at the hands of the exporters, and is eventually shipped abroad.

Estate cacao follows a rather different procedure. The estate technique of cacao curing has been described by Fernando (1938). The cured cacao is subjected to elaborate hand-grading on the basis of bean-size, and is stored in bags till a sufficiently large bulk has accumulated, when it is transported to the estate agents in Colombo. During the height of the cacao season, the period of storage on the estate may not exceed two to three days. On receipt in Colombo, the cacao is either sold by the estate agents to a local firm of exporters or despatched directly abroad. In the event of the cacao passing into the hands of local exporters, it may be subjected to further grading and to further storage in anticipation of a rise in prices, before being finally consigned abroad.

It should be emphasized that, in some instances, the contents of a bag of estate cacao may remain untampered with during the whole of its journey from the estate to the foreign buyer. Small-holders' cacao, on the other hand, is heterogeneous from the start, and the series of bulkings and re-gradings that this cacao experiences prevents its retaining its individuality for any considerable period. The scheme of research drawn up by the British Association of Research for the Cocoa, &c., Trades consisted in the transport to the exporters' warehouse, in Colombo, of a bag of cacao beans collected from the growers' drying-floor, and the withdrawal at various stages in the transport of samples for examination for *Ephestia* infestation. Transport in this way of an experimental bag of small-holders' cacao does not reproduce the course normally followed by small-holders' cacao; but the method serves the purpose of the present investigation, *viz.*, the determination of the sources of *Ephestia* infestation. It is conceded that the figures for the extent of *Ephestia* damage of small-holders' cacao provided by this method, will be an under-estimate.

The details of experimental procedure were as follows: In each series, about one cwt. of cracked and broken beans was selected from one or more drying-floors; the broken shells predispose the beans to *Ephestia* attack. The beans were well mixed and a random 7 lb. sample was withdrawn, packed in an insect-proof tin and despatched for examination to the British Association of Research for the Cocoa, &c., Trades, London. The remainder of the cacao was sterilized by exposure to dry heat at 150°F. (65·6°C.), which temperature is lethal to all stages of *Ephestia*. A small electric oven with a capacity of 33,000 cc. was used. The sterilized cacao was placed in a bag of the type normally used for transporting cacao. This bag was subjected to the routine storage and transport. At selected points in the transport, further 7 lb. samples were withdrawn and the rest of the bag was sterilized at 150°F.

immediately after each sampling. Eventually the experimental bag reached the exporters' warehouse in Colombo. A last 7 lb. sample was removed and the remainder of the bag was finally sterilized almost immediately before its transference to the boat for shipment to the British Association of Research for the Cocoa, &c., Trades, London. It was possible, by an analysis of the series of samples, to reconstruct the story of the infestation of cacao in storage and transport. Sterilization by dry heat was preferred to sterilization by the use of fumigants as the latter might have had a residual repellent action upon *Ephestia*. Apart from a certain amount of dehydration, the heat treatment did not affect the cacao materially.

RESULTS

The collection of four series of samples—two series from the estates and two from the small-holders—was undertaken. Of the two estate series, one passed through a firm of exporters prior to shipment; the other series represented the type of estate cacao consigned directly abroad by the estate agents.

Estate Series 1.—The detailed history of this series is recorded below. The cacao belonged to the latter part of the small spring crop.

June 24, 1936.—One cwt. of cracked and broken beans was selected from a drying loft of the factory of Estate A. The age of the beans varied from ten days to one month from the time of picking. A 7 lb. sample (series 1, sample 1) was withdrawn.

July 1.—The remainder of the bag of cacao was sterilized and transferred to the estate stores. The store-room had 3,000 sq. feet of cemented floor-space and formed the ground floor of a four-storeyed building, the upper floors of which functioned as drying-lofts. The presence of drying lofts above and of an adjacent copra-dryer resulted in a rather high air temperature. Approximate estimates of average day temperatures of various floors were : ground floor 80°F., 1st floor 100°F., 2nd floor 120°F., 3rd floor 120°F. The store-room was well-lighted, well-ventilated and comparatively clean. Illumination and cleanliness of stores are of importance in view of the negative phototropism and the omnivorous habits of *Ephestia*. Copra was stored alongside the cacao.

August 17.—Sample 2 was withdrawn from the experimental bag which was then sterilized and despatched by rail, along with other bags of estate cacao, to the estate agents in Colombo.

August 21.—The bag arrived in Colombo.

August 22.—Sample 3 was withdrawn.

August 24.—The sterilized bag was transferred to the estate agents' warehouse, where it was stored along with other bags of cacao. A few damaged beans filled with the frass characteristic of *Ephestia*, were observed on the premises.

September 29.—Sample 4 was withdrawn.

October 3.—The sterilized bag was placed in storage in the warehouse of exporters.

November 9.—Sample 5 was withdrawn and the sterilized bag placed again in storage in the exporters' warehouse.

December 8.—Sample 6 was withdrawn and the sterilized bag placed again in storage in the exporters' warehouse.

December 15.—It was anticipated that the exporters would attend to the despatch of the bag. As the exporters' shipments were unexpectedly delayed, the bag was transferred back to the warehouse of the estate agents who undertook to forward the bag to London.

December 24.—The bag was removed from the estate agents' warehouse.

December 26.—The bag was shipped to London.

The results of the analysis by the British Association of Research for the Cocoa, &c.. Trades, of the 7 lb. samples which constituted the above series are given in Table I.

The most noteworthy feature in the analysis is the apparent freedom of the drying floors from *Ephestia* infestation. The following experiment provided further evidence of the cleanliness of the drying floors. A representative 2 lb. quantity of cracked and broken beans removed from a drying loft of Estate A was incubated under conditions of protection from further insect infestation. Simultaneously two bags of cacao of about 1 cwt. each were drawn from the same source. One of the bags was sterilized at 150°F. Both sterilized and unsterilized bags were transferred to the estate stores on July 1, 1936. On August 19, random samples were drawn from each of the three treatments; each sample consisted of 700 unfragmented beans and ½ oz. of fragmented beans. The results of the analysis of the three samples are given in Table II. The sample drawn from the drying-loft and protected from further infestation, showed no trace of *Ephestia* or *Araecerus*.

TABLE I

No. of Sample.	Sampling details.	Time from drying-floor in days.	Damage by* *Ephestia*	Presence of *Ephestia*.
1	Drawn from drying-loft	0	–	Nil
2	After 47 days in estate store	54	+ (0·3%)	Nil
3	On arrival in Colombo	59	+ (0·3%)	Nil
4	After 35 days in warehouse of estate agents	97	+ (0·3%)	Nil
5	After 37 days in warehouse of exporters	138	+ (0·3%)	Nil
6	After further 29 days in warehouse of exporters	167	+ (0·3%)	Nil
	(Bag forwarded to London by estate agents after delay in shipment by exporters.)			
7	On arrival in London	229	+ (0·75%)	Live larvæ

* + Indicates damage, and – indicates absence of damage.

TABLE II.

Treatment	Number of beans damaged by		Number of *Ephestia*			Number of *Araecerus*		
	Ephestia	*Araecerus*	Larvae	Pupae	Adults	Larvae	Pupae	Adults.
1. Cacao drawn from drying loft and protected from further infestation	0	0	0	0	0	0	0	0
2. Cacao drawn from drying loft and exposed to infestation in estate stores	13	5	3	0	0	2	0	0
3. Cacao drawn from drying loft, sterilized and then exposed to infestation in estate stores	11	2	1	0	0	1	0	1

Estate Series 2.—Details of this series are recorded below. The cacao was collected towards the end of the small spring crop :—

July 9, 1936.—One cwt. of cracked and broken beans was removed from a drying-loft of the factory on estate B. The age of beans was one month from the time of harvesting. A 7 lb. sample (series 2, sample 1) was withdrawn.

July 16.—The sterilized bag was deposited at the estate stores. The factory on estate B was a three-storeyed building, the two upper floors of which served as drying-lofts. A verandah on the topmost floor functioned as the store-room. The slatted wooden floor of the store-room differed from that of the adjacent drying-loft only in that it was not heated by hot air from the flue. The store-room was exceptionally clean, extremely well-lighted and ventilated, and had an average air temperature of 80°F.

August 28.—Sample 2 was withdrawn.

August 31.—The sterilized bag was despatched by rail to the estate agents in Colombo.

September 2.—The bag arrived in Colombo.

September 4.—Sample 3 was withdrawn.

September 7.—The sterilized bag was transferred to the warehouse by the estate agents.

October 12.—Sample 4 was withdrawn.

October 14.—The sterilized bag was transferred back to the warehouse of the estate agents.

October 24.—Sample 5 was withdrawn. The remainder of bag was left unsterilized on account of the short time available before despatch.

The results of the examination by the British Association of Research for the Cocoa, &c., Trades of this series of samples, are presented in Table III.

TABLE III.

No. of Sample.	Sampling details.	Time from drying-floor in days.	Damage by* *Ephestia*.	Presence of *Ephestia*
1	Drawn from drying-loft	0	—	Nil
2	After 43 days in estate store	50	—	Nil
3	On arrival in Colombo	57	—	Nil
4	After 35 days in warehouse of estate agents	95	—	Live larvæ and dead adults
5	After further 10 days in warehouse of estate agents and just prior to shipment	107	+	Live larvæ
6	On arrival in London	174	+ (1%)	None alive

* + Indicates damage, and – indicates absence of damage.

Small-holders' Series 1.—The details of this series are given below. The cacao was collected from the early part of the main autumn crop.

October 23, 1936.—Nearly 1 cwt. of partially dried beans was secured in quantities ranging from 3 lb. to 33 lb. from drying-platforms of eight small-holders in Wattegama. The age of beans was about 3 days from the time of picking. The beans were thoroughly mixed and a 7 lb. sample (sample 1) was withdrawn. Sun-drying of the remainder was continued.

October 31.—Sun-drying of the cacao was completed. Sample 2 was withdrawn.

November 4.—The sterilized bag was deposited at the warehouse of a petty dealer in Wattegama. This type of dealer often buys imperfectly dried cacao from small-holders, and completes the drying operation himself.

December 12.—Sample 3 was withdrawn.

December 18.—The sterilized bag was deposited at the warehouse of a petty dealer in Kandy.

January 25, 1937.—Sample 4 was withdrawn. The sterilized bag was despatched to Colombo. Small-holders' cacao at this stage would normally have been transferred to the warehouse of a petty dealer in the Pettah, Colombo. Unfortunately, attempts at inducing petty dealers in the Pettah to handle this series failed.

February 2.—The bag reached the warehouse of the exporters. Sample 5 was withdrawn and the sterilized bag was placed in storage in the exporters' warehouse. A very large percentage of the cacao handled by this firm of exporters consisted of small-holders' cacao supplied by petty dealers in the Pettah. The quantity of cacao that passed through this firm was, however, relatively small. This firm dealt mainly in rubber and desiccated coconut, a considerable quantity of which was in storage in the warehouse at the time. The experimental bag was stored alongside cacao supplied by petty dealers in the Pettah. Some of this cacao was badly infested. On opening some of these bags *Ephestia* moths escaped. Many beans showed *Ephestia* damage. Illumination of the warehouse was poor.

March 8.—Sample 6 was withdrawn and the sterilized bag transferred back to the warehouse of the exporters.

March 22.—Sample 7 was withdrawn.

March 25.—The sterilized bag was transferred to the warehouse of another firm of exporters.

April 6.—The bag was shipped to London.

The results of the analysis of the above series of samples by the British Association of Research for the Cocoa, &c., Trades, is recorded in Table IV.

TABLE IV.

No. of Sample.	Sampling details.	Time from drying-floor in days.	Damage by* *Ephestia*.	Presence of *Ephestia*.
1†	Drawn from drying-floors	0	–	Nil
2	On completion of drying	8	–	Dead adults and pupae
3	After 38 days in warehouse of petty dealer in Wattegama	50	–	Nil
4	After 38 days in warehouse of petty dealer in Kandy	94	–	Nil
5	On arrival in Colombo	102	–	Nil
6	After 34 days in warehouse of exporters	136	+	Nil
7	After further 14 days in warehouse of exporters	150	+	Nil
8	On arrival in London	236	+	Nil

* + Indicates damage, and – indicates absence of damage.

† This sample was drawn before drying was complete and became mouldy during transit to London.

Small-holders' Series 2.—Details of this series are presented below. The cacao belonged to the latter part of the small spring crop.

August 29, 1937.—Nearly 1 cwt. of cracked and broken beans was collected from drying-platforms of small-holders in Ampitiya and Katugastota. The age of the beans was 3–5 days from the time of harvest. The beans were well mixed and a 7 lb. sample (Sample 1) was withdrawn. Sun-drying of the rest of the beans was continued.

September 6.—Sun-drying of the cacao was completed. Sample 2 was removed.

September 7.—The sterilized bag was deposited at the warehouse of a petty dealer in Katugastota.

October 15.—Sample 3 was withdrawn.

October 20.—The sterilized bag was deposited at the warehouse of another petty dealer in Katugastota.

November 27.—Sample 4 was withdrawn. The sterilized bag was despatched to Colombo.

December 2.—The bag arrived in Colombo. Sample 5 was withdrawn. The sterilized bag was transferred to warehouse of a petty dealer in the Pettah, Colombo.

January 11, 1938.—Sample 6 was withdrawn.

February 4.—The sterilized bag was shipped to London by a firm of exporters.

The results of the analysis of this series of samples by the British Association of Research for the Cocoa, &c., Trades, is given in Table V.

TABLE V.

No. of Sample.	Sampling details.	Time from drying-floor in days	Damage by* *Ephestia*.	Presence of *Ephestia*.
1†	Drawn from drying floor	0	–	Nil
2	On completion of drying	8	–	Nil
3	After 38 days in warehouse of a petty dealer in Katugastota	47	+	Pieces of adult moths of *E. cautella*.
4	After 38 days in warehouse of another dealer in Katugastota	90	+	Nil
5	On arrival in Colombo	95	+	Nil
6	After 40 days in warehouse of dealer in the Pettah, Colombo	135	+	Nil
7	On arrival in London	211	+	Nil

* + Indicates damage, and – indicates absence of damage

† This sample was removed before completion of drying and turned mouldy during transit to London.

DISCUSSION

The unsatisfactory state of the classification of the genus *Ephestia* has resulted in considerable confusion regarding the relative importance of various species of this moth in cacao infestation. Characters used for separating *Ephestia* species are either unreliable or involve elaborate micro-dissection. It has become customary to place *Ephestia* moths associated with cacao spoilage in the species *elutella* on account of the popular name "cacao moth" assigned to the latter. Results of recent investigations by Nicol (1935) suggest that *E. cautella* may probably prove as damaging a pest of stored cacao as *E. elutella*. *E. cautella* had hitherto been considered an unimportant pest of Ceylon cacao (Hutson, 1932). In the course of the present survey both *E. elutella* and *E. cautella* have been identified on Ceylon cacao, and it is likely the *E. cautella* is not as innocuous as was formerly supposed.

The most consistent feature in the four series was the apparent freedom of the drying floors from *Ephestia* infestation. In the first estate series, slight invasion occurred in the estate stores; the percentage of damaged beans after 1½ months storage was 0·3 per cent. No further damage was apparent till the bag of cacao left the exporters' warehouse. In the second estate series, on the other hand, the bag of cacao arrived in Colombo free from insect damage and from traces of insect life. *Ephestia* damage became evident only after the bag had remained in storage at the warehouse of the estate agents for about a month. The percentage of damaged beans in the bags belonging to the first and second estate series on arrival in London, were 0·75 and 1 per cent. respectively. The relatively low percentages are, at least in part, due to intermittent sterilization, and should not be considered valid estimates of the extent of *Ephestia* damage in cacao of estate origin.

Comparable results were obtained with the two small-holders' series. The cacao drawn straight off the drying-floor was free from insect damage. In the first small-holders' series, the sample drawn on completion of drying at the hands of the local petty dealer contained adults and pupæ of *Ephestia*. Despite the absence of *Ephestia* damage in the sample, this dealer's warehouse should be considered a seat of infestation. The cacao reached Colombo undamaged by *Ephestia*, and it was only after about a month's storage at the exporters' warehouse that visible injury occurred. In the second small-holders' series, *Ephestia* damage was evident after about a month's storage in the warehouse of the first petty dealer.

Most authorities have considered drying floors potential seats of *Ephestia* infestation. Knapp (1921), Patterson (1928) and Munro and Thomson (1929) among others, have entertained the possibility of drying-floor infestation. Noyes (1930) stated that moths deposit their eggs at night on beans exposed on drying platforms. (In Ceylon, at least, cacao is not left exposed on drying-platforms at night). Granato (1909) even reported the attack of cacao pods by *E. elutella* in Brazil. The apparent freedom from *Ephestia* of drying-floors of both estates and small-holders in Ceylon is accordingly of considerable interest. The cleanliness of small-holders' drying-floors and of estate barbecues where dehydration is effected by insolation, may, at least in part, be explained by the pronounced negative phototropism of both the larva and the adult of *Ephestia*. The relatively high temperatures occurring in estate drying lofts may possibly inhibit *Ephestia* development or may deter oviposition by the females. Exposure to a temperature of 55°C. (131°F.) for 40 to 45 minutes is lethal to all stages of *Ephestia* (Noyes, 1930). Lower temperatures may destroy stages of *Ephestia* other than the egg. All stages in storage subsequent to the drying floor—including warehouses of petty dealers, estate agents and exporters—may legitimately be suspected of being seats of *Ephestia* infestation. There is no evidence that infestation occurs during the actual process of transference between stores. As warehouse infestation is intensified by long storage, transport of cacao should be speeded up all the way from the estate to the boat. The practice of keeping cacao in storage till the advent of satisfactory market conditions should be discouraged. The periodic bulking and grading of peasants' cacao create conditions ideal for the distribution of the insect population throughout the beans. Estate cacao is more fortunate and there is a particularly high probability of its escaping infestation if shipped directly abroad by the estate agents; under these circumstances, estate cacao would escape contact with peasants' cacao.

In attempts at cleaning up seats of infestation, the preference of moths for the dark and for still air, and the not too fastidious feeding habits of the larva should be borne in mind. Too much emphasis cannot be placed on the importance of scrupulous cleanliness and of satisfactory illumination and ventilation of cacao warehouses. Warehouse floors should be frequently swept, and walls and ceilings frequently whitewashed. The floors should be of cement ; wooden floors accumulate quantities of cacao débris between boards. The marked seasonal periodicity of the cacao crop facilitates off-season cleaning up of cacao warehouses.

It has been suggested that this periodic clean-up may be advantageously supplemented by fumigation of warehouse interiors with hydrogen cyanide or ethylene oxide. But fumigation is not likely to be profitable if facilities for making warehouses airtight do not exist or if warehouses contain numerous crevices. *Ephestia* larvæ lodged in crevices may escape damage even when lethal concentrations of the fumigant occur in the more exposed situations. A further disturbing factor is the occurrence of what is sometimes known as " protective stupefaction " : larvæ which succumb to the immediate application of a certain concentration of fumigant may, if previously subjected to sub-lethal doses, resist a subsequent application of that lethal concentration (Potter, 1937). A rather more efficient method of sterilizing warehouses is the spraying of warehouse interiors with a solution of pyrethrins in a white oil. The sprayed interiors are provided with a protective film of insecticide which possesses considerable residual properties and prevents re-infestation. Spraying should be done twice a week during periods of moth emergence (Potter, 1938).

In instances where complete extermination is not practicable, the survival level of *Ephestia* may be lowered by the use of moth-traps ; tea made up in the usual way with milk and sugar provides an efficient lure. The possibilities of biological control by the use of the small Braconid wasp, *Microbracon* (*Habrobracon*) *hebetor* Say., which is predacious on species of *Ephestia*, may be profitably explored. Numbers of limp *Ephestia* larvæ paralysed by this Braconid may sometimes be seen on sacks of cacao. The liberation of these parasites in cacao warehouses has been advocated as a measure of *Ephestia* control. The life cycle of the parasite is conveniently short, and a single parasite can destroy several *Ephestia* larvæ. The fact that the larvæ which is the only susceptible phase of *Ephestia*, spends most of its days inside the cacao bean in a situation inaccessible to the parasite, interferes with successful control. It is only when the larva emerges from the bean prior to pupation, that it is exposed to

attack by the Braconid. For effective control it is essential to ensure a high population of parasites at this particular time (Noyes, 1930). Another parasite which shows considerable promise is *Trichogramma minutum* Riley (Chaboussou, 1937).

The orientation of sacks in storage appears to affect the degree of infestation to some extent (Wadsworth, 1933). The upper end of a bag stood end on, has a relatively large air space suitable for pupation of the larvæ and mating of the moths. Sacks should be stacked on their sides.

In Ceylon, both estate cacao and small-holders' cacao undergo vigorous washing at the end of the sweating operations. This washing contributes to the attractive appearance of the final product, but makes the shell brittle and consequently liable to *Ephestia* invasion. The risk of prejudicing buyers abroad would, however, prevent Ceylon growers from dropping the practice. Besides, the danger of moulding is considerably reduced by washing. The fact that Criollo beans are more susceptible to *Ephestia* attack than Forastero beans is of some interest in view of the present change-over from Criollo to Forastero types in Ceylon plantations.

One of the most promising recent developments in *Ephestia* control is use of leaves of neem (*Melia azadirachta* L.) as an *Ephestia* repellent. Sacks of cacao beans lined with air-dried neem leaves have been maintained free from *Ephestia* in a heavily infested environment. The neem appears to discourage oviposition by the females or to repel young larvæ. The leaves should not be mixed with the beans in the sack as this would necessitate re-winnowing (Anon., 1938).

SUMMARY

1. The methods employed and the results obtained in an investigation undertaken by the British Association of Research for the Cocoa, Chocolate, Sugar Confectionery and Jam Trades, London, in collaboration with the Department of Agriculture, Ceylon, into the sources of *Ephestia* infestation of stored cacao, in Ceylon, are presented.

2. The freedom from *Ephestia* of cacao drying-floors of both estates and small-holders, is demonstrated.

3. Stages in storage subsequent to the drying-floor, including warehouses of petty dealers, estate agents and exporters, are shown to be seats of *Ephestia* infestation.

4. Methods of *Ephestia* control are indicated in outline.

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THE INFLUENCE OF SPACING, RIDGING AND SEEDLING NUMBER PER HILL ON THE YIELD OF CHILLIES (CAPSICUM FRUTESCENS L.)

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CHILLIES and tobacco are the peasant's most important money crops in the Jaffna peninsula. Chillies are grown in the peninsula under irrigation, in rotation with paddy, tobacco, millets and cassava. Seedlings raised in nurseries are, when from four to six weeks old, transplanted into the field at the rate of two to four per hill. The hills are usually spaced 3 ft. by 3 ft. and are either on ridges or on the flat. Although certain well-established methods of cultivation are adhered to in the growing of chillies, little exact information exists regarding the relative advantages of various methods. This paper reports the results of an experiment designed to determine the effects of spacing, ridging and seedling number per hill on the yield of chillies. The experiment was set down at the Experiment Station, Peradeniya, during the *maha* season, 1938–39.

DESIGN OF THE EXPERIMENT

Treatments.—Details of the three sets of factors investigated, *viz.*, seedling number per hill, ridging and spacing, are presented in Table 1. The design of the experiment was factorial, *i.e.*, it included all possible combinations of the three sets of factors.

TABLE 1.

Seedling Number	Ridging	Spacing
N_0 : 2 seedlings per hill ..	R_0 : planting on the flat	S_0 : close—3 ft. × 2 ft.
N_1 : 4 seedlings per hill ..	R_1 : planting on ridges ..	S_1 : wide—3 ft. × 3 ft.

System of replication.—An experiment with complete replication of the eight treatments within each block would have had an undesirably large block size and a consequently large error variance. The adoption in the present experiment of the process of partial confounding permitted the reduction of both block size and error variance. By sacrificing part of the information on the three first-order interactions and the one second-order interaction, it was possible to secure an increase in the accuracy of the direct effect comparisons (Fisher, 1936 and Yates, 1933 and 1937). The distribution of the eight treatments over the four pairs of blocks of four plots each, is illustrated in Table 2.

TABLE 2.

Interaction confounded	$N \times R \times S$		$N \times R$		$N \times S$		$R \times S$	
Block	IA	IB	IIA	IIB	IIIA	IIIB	IVA	IVB
Treatments	$N_0 R_0 S_0$	$N_1 R_0 S_0$	$N_1 R_0 S_0$	$N_0 R_0 S_0$	$N_1 R_0 S_0$	$N_0 R_0 S_0$	$N_0 R_1 S_0$	$N_0 R_0 S_0$
	$N_1 R_1 S_0$	$N_0 R_1 S_0$	$N_0 R_1 S_0$	$N_0 R_0 S_1$	$N_0 R_0 S_1$	$N_0 R_1 S_0$	$N_0 R_0 S_1$	$N_1 R_0 S_0$
	$N_1 R_0 S_1$	$N_0 R_0 S_1$	$N_1 R_0 S_1$	$N_1 R_1 S_0$	$N_1 R_1 S_0$	$N_1 R_0 S_1$	$N_1 R_1 S_0$	$N_0 R_1 S_1$
	$N_0 R_1 S_1$	$N_1 R_1 S_1$	$N_0 R_1 S_1$	$N_1 R_1 S_1$	$N_0 R_1 S_1$	$N_1 R_1 S_1$	$N_1 R_0 S_1$	$N_1 R_1 S_1$

A separate interaction is confounded within each pair of blocks. The second-order interaction $N \times R \times S$ is, for instance, confounded between the components of the first pair of blocks, which accordingly provide no information on this interaction. Complete information on the interaction $N \times R \times S$ is, however, contributed by the other three pairs of blocks.

Size of plot.—Each plot was 1/42 acre and contained four rows of hills spaced 3 ft. between rows and either 2 ft. or 3 ft. within rows. In the collection of data, a strip $4\frac{1}{2}$ ft. wide was rejected at each end of the plot. The nett area contributing data was hence 1/47 acre.

EXPERIMENTAL MATERIAL AND METHODS

The nursery.—Five cwt. of compost were spread over 570 sq. ft. (1/77 acre) of nursery bed and well mixed with the surface

soil in September, 1938. Seed of the variety Elephant's Trunk obtained from the Experiment Station, Jaffna, was sown in drills 3 in. apart.

Sowing Dates.	Quantities of seed sown.
September 16, 1938	8 oz.
,, 17, ,,	8 oz.
,, 28, ,,	$1\frac{1}{2}$ oz.

A certain amount of damping-off occurred in the nursery. The application of a 0·6 per cent. solution of potassium permanganate (1 oz. per gall.) at the rate of one quart per square foot of nursery bed appeared to check the disease. Seedlings corresponding to sowing dates September 16 and 17 were topped on November 3 ; the average height of the seedlings at the time was 7–9 in.

The field.—The experimental area had carried a crop of *Pennisetum typhoideum* Rich. during the *yala* season (March to July) 1938. The land was ploughed on October 3, 1938, and received an application of $11\frac{1}{2}$ tons of compost per acre on October 11 and 12. The land was then disc-harrowed in two directions on October 13, and spike-harrowed on. October 18. Plots set apart for ridge-planting were ridged with a ridging plough on November 5 and 6. Plots in which planting was to be on the flat were levelled on November 7. Seven-weeks-old seedlings were planted out in the field on November 7. It was found necessary to hand-water the area on November 15, as there had been no rain since the date of transplanting ; approximately one pint of water was applied per hill. Hand-watering was repeated on November 29 and December 9. The seedling stand was poor on account of the drought. Vacancies were supplied on November 17 and 18 and again on December 22. The unridged plots were weeded on December 1 and 2. The ridged plots appeared comparatively clean and were accordingly left unweeded. Flowering was first observed on December 6.

Incipient leaf-curl was effectively checked by spraying the plants on December 27 and 31, 1938, and on January 13 and 17, 1939, with lime-sulphur at a concentration of $1\frac{1}{2}$ oz. per gallon. About 28 gallons of spray mixture were needed for the area.

Applications of sulphate of ammonia at the rate of 4 lb. per plot were made on January 3 and 4, 1939. The fertilizer was applied in pinches to the bases of the plants and forked in. The plots were harvested on January 1, February 2 and February 15.

METEOROLOGICAL DATA

Relevant rainfall records are presented in Table 3. Days of no rain are omitted.

TABLE 3.

Date	Rainfall in.	Date	Rainfall in	Date	Rainfall in.
1938		1938		1938	
Sept. 16	·18	13	·02	17	·25
17	·55	14	·01	19	·13
18	·03	23	·42	20	·16
19	·28	27	·82	21	2·13
22	·94	28	·41	22	·06
23	1·33	31	·68	23	1·08
25	·24	Nov. 1	1·03	24	·42
26	·16	2	1·53	25	·25
27	1·13	3	·35	26	·21
28	·81	5	·49	27	·29
29	·66	6	·25	28	·10
30	·42	10	·01		
Oct. 1	·16	16	·35	1939.	
2	·03	17	2·57	Jan. 8	·09
3	·04	18	1·34	9	2·98
4	·26	19	·04	10	2·34
5	·22	21	·02	11	·01
7	·04	26	·06	12	·05
8	·48	Dec. 4	·10	17	·49
9	·62	7	·05	18	·76
10	·24	13	·19	19	·02
11	·01	15	·29	Feb. 15	·02
		16	·06		

RESULTS

Records of the vacancies provided estimates of the effects of various factors on the stand of transplanted seedlings. An analysis of variance of these records is presented in Table 4.

TABLE 4

Analysis of Variance of Numbers of Vacancies.

	D. F.	Sum of Squares	Variance
Blocks	7	47,667·75	6,809·7
Direct effects	3	217,382·3	72,460·8
Interactions	4	28,045·9	7,011·5
Error	17	59,476·55	3,498·6
Total	31	352,572·5	

The value of F for total treatments greatly exceeds the one per cent. point; the treatment effects are hence highly significant. The standard errors for the estimates of direct effects and interactions are $\sqrt{32 \times 3498 \cdot 6}$ and $\sqrt{24 \times 3498 \cdot 6}$ respectively.

Fisher's t test indicated that the effects of ridging and of seedling number per hill were significant at the one per cent. level. The various interactions and the effect of spacing were not significant. The results are presented in Tables 5 and 6.

TABLE 5

Numbers of Vacancies

(8/47 acre)

	Flat-planting	Ridge-planting	Means
Two seedlings per hill	313	483	398
Four seedlings per hill	961	2,074	1,517·5
Means	637	1,278·5	957·75

TABLE 6

Numbers of Vacancies

(8/47 acre)

	Flat-planting	Ridge-planting	Means
Close spacing	681	1,507	1,094
Wide spacing	593	1,050	821·5
Means	637	1,278·5	957·75

Yields in the experimental season were poor on account of the continued drought. It was not possible to take more than three pickings off the area. The total yields have been subjected to an analysis of variance in Table 7.

TABLE 7

Analysis of Variance of Yields

	D. F.	Sum of Squares	Variance
Blocks	7	12,732·875	1,818·98
Direct effects	3	40,433·75	13,477·92
Interactions	4	7,270·5	1,817·6
Error	17	15,237·75	896·34
Total	31	75,674·875	

The value of F for total treatments greatly exceeds the one per cent. point and hence indicates significance. The standard errors for estimates of main effects and interactions are $\sqrt{32 \times 896 \cdot 34}$ and $\sqrt{24 \times 896 \cdot 34}$. The application of Fisher's t test showed that effects of spacing and of seedling number per hill were significant at the one per cent. level. The various interactions and the effect of ridging were not significant. The results are presented in Tables 8 and 9.

TABLE 8

Yields in cwt. per acre

	Flat-planting	Ridge-planting	Means
Two seedlings per hill ..	3·13 ..	3·29 ..	3·21
Four seedlings per hill ..	4·03 ..	4·17 ..	4·10
Means	3·58 ..	3·73 ..	3·66

TABLE 9

Yields in cwt. per acre

	Flat-planting	Ridge-planting	Means
Close spacing	4·35 ..	4·60 ..	4·47
Wide spacing	2·82 ..	2·86 ..	2·84
Means	3·58 ..	3·73 ..	3·66

DISCUSSION

Abnormal weather prevailed during the period of the experiment the results of which are accordingly of rather limited application. Monthly precipitation was well below the average for previous years, and the crop which was almost completely rain-fed was subjected to a protracted period of drought. The average yield over the experimental area was only 3·7 cwt. per acre.

In the statistical analysis of the records of vacancies, the significance of the effect of seedling number per hill is of little interest. A significantly better stand was obtained with flat-planting than with ridge-planting. The number of vacancies on the ridges was over double that on the flat. The increase in casualties consequent on ridging was estimated at 3,769 per acre. The poor stand associated with ridging was probably due to the occurrence, after transplanting, of a prolonged dry spell, during which plants on ridges, on account of their greater root exposure, would have experienced severer drought conditions than plants on the flat. Ridging did not produce a significant increase in yield and did not exhibit any incidental advantages that might have justified the extra expenditure incurred.

The effects of spacing and of seedling number per hill on yield were both significant and considerable. The closer spacing and the higher seedling number per hill produced increases in yield of 1·63 cwt. and 0·89 cwt. per acre respectively. The poor shoot and root growth consequent on the prevailing drought explains this association of increased yields with increase in plant number per unit area. It is probable that the repetition of this experiment in a wet season would reveal a significant interaction of season with spacing and with seedling number per hill.

SUMMARY

An experiment designed to determine the effects of spacing, ridging and seedling number per hill on the yield of chillies was laid down at the Experiment Station, Peradeniya, during the *maha* season, 1938-39.

The stand of transplanted seedlings on the flat was significantly superior to that on the ridges.

Significantly higher yields were obtained with the closer spacing (3 ft. by 2 ft.) and with the higher seedling number (four per hill), *i.e.*, increase in plant number per unit area was accompanied by increase in yield.

ACKNOWLEDGMENT

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A NOTE ON THE COCONUT CATERPILLAR IN THE BATTICALOA DISTRICT

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IN the old days, the coconut caterpillar in the Batticaloa District was an "annual affair", and nobody took very much notice of it. It made its appearance about June or July each year (during the "land wind" period), and faded out when the north-east monsoon came in. It did not do much damage, as it attacked isolated portions of the District only. But in 1920, the attacks became more serious and widespread, and the Entomological Division of the Department of Agriculture was consulted as to the best method of controlling this pest.

In 1921 the coconut caterpillar was declared a pest under the Plant Pests Ordinance, 1907, and the prescribed regulations required that the affected leaves should be cut and burned as soon as the pest made its appearance. The larger estates in the Batticaloa District carried out these instructions, but on a very large number of small estates owned by absentee proprietors, who kept only a kangany and three or four labourers on the estate, there was no supervision of these control measures, with the result that this work was seldom done by these small estates. The larger estates, therefore, found it useless to continue cutting and burning when their smaller neighbours did nothing to control the spread of this pest.

In 1934, when there was a severe recurrence of the coconut caterpillar pest, representations were made to Government by the Batticaloa District Agricultural Committee requesting that some more effective action should be taken. The Entomological Division of the Department of Agriculture then decided to try and control this pest by the breeding and liberation in large numbers of an introduced parasite *Trichospilus pupivora*. The regulations requiring the cutting and burning of infested leaves were temporarily suspended. The parasite was imported from South India and breeding stations, both at Peradeniya and Batticaloa, were started at the end of 1935. But owing to the difficulty of breeding this parasite in Batticaloa during the hot season, the Batticaloa breeding station was

closed down in September, 1936, since when parasites have been sent by post from Peradeniya to Batticaloa for liberation. During 1936, these parasites possibly contributed to the control of the pest, but the hot weather was rather too severe for them and probably only a few survived. In 1937, the outbreak of the coconut caterpillar was not so severe, but the liberation of parasites was continued. On this occasion they survived the hot weather better and the pest certainly abated. Moreover, the stoppage of the cutting and burning of affected leaves probably gave the local parasites a chance to increase and gradually to assist in the control of the pest, but it is doubtful if they could have done so unaided if the *Trichospilus* had not been introduced.

In 1938, the liberation of the *Trichospilus* parasite was continued in much larger numbers and it is hoped that, if the supply of this parasite is continued for a further period to give it every chance of acclimatizing itself to the Batticaloa District, it will assume the dominant position which it maintains in the western coconut areas in controlling the pest there. The damage done by the coconut caterpillar in this district when a severe and widespread outbreak occurs is very great, and it is estimated that a large proportion of the crop is lost for two years after one of these outbreaks. As coconuts and paddy are the two main-stays of the people of this district, the coconut caterpillar is a very serious obstacle to the well-being of the population.

Certain residents in this district, who expect rapid results to follow parasite introductions and consider that they should lead to a complete disappearance of the pest they are designed to control, are of opinion that the introduction of *Trichospilus* into the Batticaloa District has not met with successful results. It is doubtful, however, if any pest can be completely suppressed by such methods, and, at best, only periodical control over long intervals can be expected. As a practical planter of some 17 to 18 years' standing in this district, it is my opinion that the introduced *Trichospilus* parasite, although by no means entirely responsible for controlling the coconut caterpillar pest in the Batticaloa area, is playing its part in helping the local parasites to bring about this satisfactory result.

SELECTED ARTICLES

CONCLUSIONS AND RECOMMENDATIONS OF THE CONFERENCE OF COLONIAL DIRECTORS OF AGRICULTURE, HELD AT THE COLONIAL OFFICE IN JULY, 1938*

1. THE WORK OF THE IMPERIAL AGRICULTURAL BUREAUX

THE Conference desires to place on record its high appreciation of the work of the Imperial Agricultural Bureaux and of the Imperial Institute of Entomology and the Imperial Mycological Institute, and has no suggestion of major importance to make concerning the manner in which their functions are performed so far as the Colonial Empire is concerned.

It is, however, suggested that consideration might usefully be given to the possibility of providing somewhat fuller abstracts of papers which appear in publications which are normally difficult of access to workers in the Colonial Dependencies or which appear in languages with which British workers are unlikely to be familiar.

It is thought that a useful purpose would be served if arrangements could be made to supply those in charge of the Institutes and the Bureaux with lists of the publications which are normally received and filed in the Colonial Departments of Agriculture and Veterinary Services as this would afford guidance as to the amount of abstracted matter which should be provided in respect of articles appearing in particular publications.

It is also suggested that such lists could be interchanged with advantage between the various Colonial Departments as they would serve to guide the departmental authorities in the choice of publications desirable for departmental use.

The Conference further desires to express the high appreciation of Colonial workers of the critical reviews of certain aspects of agricultural research which have been from time to time issued by certain of the Bureaux and to suggest that so far as circumstances permit the continued issue of similar reviews would be welcomed by Colonial workers.

II.

In connexion with the work of the Imperial Bureaux the Conference desires to invite attention to resolution XXXIV of the Commonwealth Scientific Conference which relates to co-operation in obtaining and maintaining plant material for crop improvement.

* Extract from the *Report and Proceedings of the Conference of Colonial Directors of Agriculture*, Colonial Official Publication No. 156.

The Conference is of opinion that it is most desirable that colonial research workers should be placed in a position to know the sources from which material of the recognized varieties of cultivated crops could be obtained and the nature of the varieties available.

To this end it is recommended that the Executive Council of the Imperial Agricultural Bureaux or other suitable authority should consider the possibility of taking steps to cause lists to be prepared of the recognized and established commercial varieties of the more important tropical and sub-tropical crops grown in the different territories in the Empire, and to include therein brief descriptions of the characteristics of each variety and an indication as to the sources in each territory from which planting material would be available to research workers engaged in plant improvement problems.

III.

The Conference also desires to invite attention to Resolution XXXVI of the Commonwealth Scientific Conference which relates to the control of damage by termites.

The Conference stresses the importance of active measures being taken to control the losses being occasioned by termites in the Colonial Empire and expresses the hope that the Executive Council of the Imperial Agricultural Bureaux may be able to take such steps as will lead to the collection and interchange of information on the lines recommended by the Commonwealth Scientific Conference at as early a date as may be possible.

In particular it is desirable that material showing the various stages of the development of the different species of termites which occur in the Colonial Empire, together with an account of their distribution and the character of the damage done by them, should be submitted to the Imperial Institute of Entomology, with a view to establishing the species which should be regarded as dangerous and destructive and to determining their distribution.

The Conference desires to lay stress on the importance of securing the active collaboration of other Government authorities with the official Entomologists in termite investigations and particularly that of the Public Works Departments.

2. SOIL CONSERVATION

The Conference recognizes that the importance of soil conservation cannot be over-stressed. Increased attention has been given to this matter in recent years throughout the Colonial Empire and a sound public opinion is being formed in favour of soil conservation, the prevention and check of accelerated erosion and the maintenance of soil fertility. In many Colonial dependencies active steps have been taken to check accelerated erosion and further action is contemplated. It is recognized that the chief asset of the colonial peoples is the soil and that economic policy requires to be planned on soil fertility and productivity.

Accelerated erosion takes place when there is an interference with the vegetative cover and it is necessary to recognize that lands should be utilized for

the purposes for which they are best fitted, due regard being given to the maintenance of adequate forest and grass cover, especially in hilly districts and for the protection of the springs and water supplies. Nature dictates that some lands should always be maintained in forest cover, others are suited for grassland development whilst others are fitted for cultivation.

Ecological surveys should be a preliminary to the planning of land utilization and where development has progressed general agricultural and economic surveys are also desirable as a necessary preliminary to schemes designed to improve conditions or to introduce new systems of husbandry, which aim at increasing soil fertility or the improvement of soil structure. The Conference is of the opinion that further investigational work is necessary to ascertain the scientific causes of crumb formation and of those factors which lead to soil stability.

In agricultural practices attention should be given to all measures designed to effect soil stability, improve fertility and check erosion. These measures must vary with circumstances, with the differing characters of soils and climatic conditions and with the crops under cultivation. Some crops are liable to induce accelerated erosion more readily than others and in agricultural practices the aim should be to encourage contour ploughing or planting and the development of a satisfactory land cover at least during the periods which are dangerous from an erosion point of view.

Erosion occurs in widely varying forms in different types of country, each calling for the application of measures which may be found to be locally suitable. These measures should naturally be designed to slow down the movement of soil by either wind or water by every economic means possible and should include the protection and restoration of vegetation and the erection, where necessary, of structures to slow down and spread the movement of water.

Importance is attached to the use of vegetation control in attempts to check erosion and the Conference desires to record its opinion that simple measures should always be explored before works of an engineering character or of a costly nature are contemplated. Schemes of erosion control should be based upon drainage areas and work should invariably start at the head of the natural drainage channels or at the sources of the erosion trouble. The maintenance of forests or other vegetative cover on high lands and at the heads of natural drainage channels is of the utmost importance.

The Conference recognizes that soil conservation work is the duty of all and that it is unlikely to be successful, owing to the varied and far-reaching problems involved, unless a policy of close co operation is established between the Administration, all technical departments of Government, all local Authorities and the people. It desires to emphasize that it is essential to get down to the people themselves in order to arouse their interest in the problems and to secure their willing collaboration. The creation of an informed public opinion is an essential to success. Collaboration and co-operation may be effected by the formation of local Committees and the direct interest of the people may be aroused by the establishment of good demonstration areas of adequate size at well selected and important centres. In these demonstration areas it is necessary not only to show how anti-erosion measures can be successfully

carried out but to demonstrate the proper utilization of land and the methods of crop and animal husbandry designed to assist in soil conservation and the maintenance of fertility. The development of sound systems of agriculture is as essential in soil conservation work as are measures against erosion, even in areas where erosion is already assuming serious proportions.

The importance of dams to intercept run-off cannot be over-emphasized and the Conference has noted with satisfaction the valuable results which have been achieved in Basutoland as a consequence of the creation, as part of the scheme for erosion control, of small dams and the establishment of terraced fruit and vegetable gardens. In pastoral areas the importance of improved and increased water supplies also cannot be overstressed : the creation of such supplies assists in the better utilization of the pastures.

The conference wishes also particularly to emphasize the important role which Administrative Officers should play in all matters connected with the planned utilization of lands and soil conservation control. On them falls the duty, in collaboration with technical officers, of arousing interest amongst the agriculturists or pastoralists in the erosion problems with which they are faced, in stimulating the effective working of local committees, in encouraging effective co-operation and in smoothing out the difficulties which face technical officers charged with soil conservation duties. It recommends also that the subject of land utilization and of soil conservation and the part which Administrative Officers can play in these matters should take an important place in the courses provided at Oxford and Cambridge during the training period for Administrative Officers prior to their assumption of duties in the Colonial Service. It is suggested that in these courses the wide and important nature of the subject should be emphasized and the necessity for the fullest co-operation between all branches of the Colonial Service stressed.

Technical officers with experience in soil conservation work are necessary in many of the Colonial dependencies for executive duties and for effecting liaison between the several departments and between those departments and Administrative Officers. The Conference is of the opinion that the best interests will be served if these officers are regarded as liaison officers rather than purely executives. Work on soil conservation and even work connected with anti-erosion measures concern a large number of departments and an even greater number of individuals. It would be impossible to expect satisfactory progress if executive works were entrusted solely to soil conservation officers as their numbers could not be adequate to the task which has to be faced in the Colonial Empire. Officers with specialist knowledge of and experience in soil conservation measures are essential to progress and all plans formulated by local committees or by departments should be examined and approved by competent technical authorities before they are put into operation.

The value of an interchange of visits is emphasized and the Conference recommends that provision should be made for officers concerned with soil conservation to visit neighbouring territories or even farther afield in order to study measures which have been adopted to deal with erosion or with other matters concerning the conservation of soil and its fertility. It also feels that

farmers engaged in soil conservation operations should be enabled to exchange visits from time to time and that organized visits by them to demonstration areas should be arranged.

In the matter of de-stocking the Conference recognizes that this may be necessary in certain areas where soil erosion has assumed serious proportions and where stock concentrations are high, but it does not overlook the difficulties which have to be faced. The education of responsible leaders on the need for de-stocking under certain conditions is regarded as being the first essential, and it is felt that progress in the development of a public opinion in favour of stock reduction will follow efforts to establish a commercial outlet for stock and animal products. Efforts in this direction may include the development of great numbers of market centres and the encouragement of butchers' shops at these centres and elsewhere. An increase in the centres for drying hides and skins is also necessary in some areas and, as far as cattle are concerned, the development of dairy undertakings and the preparation of ghee should be encouraged. Improvement schemes designed to enable the stock owners to secure from a reduced number of good, well-fed stock a financial return which is not less than that previously obtained from a large number of ill-fed inferior stock are certain to secure results in the long run and the denudation of the countryside caused by trampling and over-grazing will be reduced.

Pasture management plays an important role in soil conservation in grass land areas and the importance of controlled movements of stock and of controlled grazing is considered to be of the greatest importance under such conditions.

In all areas the Conference desires to express the opinion that there is a necessity for some measure of control over grass or bush burning, and that such control measures as are desirable should be established when the necessary preliminary investigational inquiries have been made.

3. ANIMAL HUSBANDRY

The Conference desires to emphasize the importance which animal husbandry must play on the development of systems of mixed farming, the value of which cannot be overstressed if soil fertility is to be maintained and the nutritional standards of the inhabitants of Colonial Dependencies improved

The Conference recognizes the valuable progress which has been made with mixed farming in the Northern Provinces of Nigeria and notes the experimental work which is being done with mixed farming in several other parts of the Colonial Empire. The trials which have been initiated recently in the Wet Tropics were recognized as being of the greatest importance and the results secured from the use of farmyard manure on Benin sands in Southern Nigeria and in other areas are of importance. It is urged that further efforts should be made to test the feasibility of the introduction of animal husbandry into the agricultural systems of the wetter areas. Interest was taken in the successful results obtained from the folding of sheep in certain parts of the forest area of the Gold Coast and in the value which followed the keeping of poultry in citrus cultivations in some areas. It is recognized that there were considerable

difficulties in effecting the introduction of animal husbandry in many areas and that the question of disease required careful consideration. In the wetter tropics it is recognized that open grazing may be difficult, and under these conditions the stall feeding of stock with forage and fodder crops provides a better alternative than grazing.

The Conference also suggests that increased attention could with advantage be paid to the part which buffaloes can play in the Wet Tropics and recommends that future work should include trials designed to ascertain how far buffaloes both of the milch type and also of the working type can be successfully employed in suitable regions in the development of mixed farming.

It is felt that extensive preliminary experiment is always necessary before mixed farming is introduced and that provision for the training of cultivators in the new methods and for establishing the more progressive of them, after training, as groups of demonstrators is essential to success.

The question of finance for the provision of the necessary stock and implements is a matter which requires special consideration and the Conference expresses the view that some provision must be made for reasonable financial assistance to selected individuals and that means should be devised to enable prospective "mixed farmers" to effect savings through co-operative thrift societies or by other means against the necessary purchases of stock and implements. It also feels that the amounts of loans and the terms of repayment should in general be in direct relation to the capacity of the farmers to repay.

Government assistance, after experimental work had been done and the necessary training provided, could in the view of the Conference best take the form of—

(1) The provision of water supplies in centres where mixed farming is being started.

(2) The provision of instructional agricultural services.

(3) The provision of reasonable financial assistance for the establishment of trainees on their holdings.

(4) The encouragement of thrift societies.

(5) The provision of adequate supplies of selected and trained stock at the lowest possible prices.

(6) The provision of implements at the lowest possible prices.

(7) The provision of veterinary services for the immunization of stock required by mixed farmers and for detection of disease and attention thereto when it occurs amongst the stock maintained by them.

(8) The development of market centres and of schemes for the orderly marketing of produce.

4. NUTRITION.

With a view to effecting a general improvement in nutrition, the Conference recognizes the importance which should be attached to increased attention being given by all Colonial Departments of Agriculture and Veterinary Services to the development of animal husbandry, the encouragement, where practicable, of mixed farming, and to the production of greater supplies, and to the greater diversification, of locally grown foodstuffs.

The nutritional problem in the Colonial Empire is basically economic and agricultural, and it can only be tackled satisfactorily if there is the closest co-operation between the Medical, Agricultural, Veterinary and Education Departments.

Generally speaking there are definite indications that emphasis should be given to the greater consumption throughout the Colonial Empire of meat and other animal products, fruit and green vegetables.

A greater consumption of meat can often be secured by increasing the number of butchers' shops and in some areas it has been found that a greater consumption of milk has followed schemes for the development of mixed farming and for the production of ghee. Milk, from which the fat has been extracted for sale, if returned to the producers at the time of separation, will, it has been proved, be taken back for consumption in the homes, the occupants of which would otherwise not have secured the milk at all, but have allowed it to be consumed by suckling stock. The development of poultry keeping also offers possibilities of considerable development, whilst there is in some areas a serious lack of fruit supplies and in certain seasons a dearth of green vegetables. Leafy spinaches and indigenous vegetables form an important part of native dietary and the Conference considers that Departments of Agriculture could profitably give greater attention to the development of vegetable gardens, especially where water supplies are available.

The Conference agrees with the suggestion that endeavours should be made to encourage the use of under-milled or good quality par-boiled rice in the place of polished white rice in all territories where rice is the staple food of diet.

It also desires to place on record that in its view the improvement of nutritional standards will follow, as has already been frequently demonstrated in many areas of the Colonial Empire, an improvement in the economic position of the people concerned, and that it is essential that the production of commercial cash crops or animal products should continue to be encouraged, in addition to the production of greater local supplies of food, if progressive improvement in the nutrition of the peoples concerned is to be achieved.

5. LAND SETTLEMENT

The Conference has taken careful note of the observations submitted on the subject of land settlement in the Colonial Empire, and of the steadily increasing importance which is being attached to this form of development as a means of providing a solution of certain social problems of pressing importance, particularly in the Caribbean area.

It feels that if development is planned along lines, the nature of which is now becoming reasonably well recognized, land settlement can do much to provide an alleviation of certain social difficulties. There are, however, limits to the possibilities of land settlement and failure to appreciate and to take account of these can only lead to disappointment and failure.

The Conference desires to stress that in all schemes of land settlement careful consideration must be given to the selection of the land and that this must be chosen by reason of its suitability for cultivation from an agricultural point

of view, its accessibility to transport facilities and to market centres. The existence of suitable provision for water supply is essential and in malarial districts steps to improve health conditions must not be overlooked.

Great importance attaches also to the selection of settlers, while provision must be made for their training after selection.

The system of tenure adopted is also of importance and whilst freehold tenure has been and is still, in certain quarters, extensively advocated, it should not be overlooked that continued supervision of the settlers by qualified officers is necessary if satisfactory results are to be achieved. Unsupervised settlement and the unrestricted possession of lands by peasant owners frequently results in unsatisfactory methods of cultivation, to fragmentation of holdings and the ultimate frustration thereby of settlement schemes. In this connexion it is emphasized that if land settlement is to be a source of permanent improvement and not merely a temporary palliative of existing difficulties it is necessary to take a long view and to plan accordingly.

The Conference considers that in all schemes it is necessary to pay the most careful attention to the systems and methods of agriculture employed and that those responsible for the supervision should be in a position to insist on the holders following cultural practices which will so far as possible ensure that the fertility of the soil on the settlement is adequately conserved.

The Conference further desires to stress that from the point of view of general efficiency a collection of small holdings is usually less efficient agriculturally than a large estate, and consequently it is desirable that a measure of co-operation should be applied in regard to the purchase of farming requirements, the provision of implements, stock and buildings and the preparation and marketing of produce.

It also desires to indicate that successful land settlement is often costly and although a part of the initial outlay may be in time recouped a proportion of non-recoverable expenditure on land settlement schemes has to be faced.

Particularly it desires to emphasize that in planning land settlement schemes due account must be taken of the crops which can be cultivated by the tenants and the markets which can be found for the produce. All schemes should include the production of as large a proportion as possible of the food requirements of the tenants themselves but there must also be included at least one cash crop if the holders are to be expected to achieve a reasonably adequate standard of living.

The Conference considers that as a prelude to the inception of land settlement schemes a survey of the economics of peasant agriculture is of the greatest value and urges that wherever possible such surveys should be undertaken before developments are embarked upon, and that when this is not possible a careful economic examination should be made of the data available.

All attempts to launch land settlement schemes without due consideration of the factors involved or the examination by the agricultural authority as to the suitability of the lands for development are to be deprecated. It is felt that there have been sufficient examples in the past of the folly of establishing land settlement schemes on unsuitable lands without adequate preliminary

inquiries or without the provision of continued instruction for the settlers. All feasible steps it is recommended should be taken to avoid a repetition of these mistakes in the future.

6. PRODUCE INSPECTION

The Conference has noted with interest the progress which has occurred in the development of schemes of inspection of agricultural produce in a number of dependencies since the last Conference in 1931.

It feels that in territories and under conditions where there is an opening for their operation the further development and extension of such systems should be considered.

Particular attention is directed to the striking measure of success which has attended efforts in this direction in certain African Territories and it is noted with satisfaction that the necessity of providing for the continuation of the service on a permanent basis in Nigeria has now been accepted.

The Conference desires to emphasize that an essential to the success of schemes of Produce Inspection lies in securing the support for them of trade interests. In Nigeria this has been secured by appointing to the Advisory Committees members of merchant firms interested in the purchase and shipment of produce.

When lack of success has occurred it is traceable in some instances to insufficient collaboration with commercial interests and to lack of propaganda designed to explain the objects of the inspection schemes to the producers prior to their introduction.

It further seems clear that Produce Inspection is only likely to produce satisfactory results where the improvement in the quality of the produce which it is sought to bring about is in accordance with the recognized demands of the market. Consequently an essential preliminary to the inception of new schemes should be the careful examination of the market requirements in regard to quality and where grading is undertaken the grades which are established should be in accordance with market standards.

Instances do, however, exist where attempts to improve the quality of exported produce may meet with success by reason of the fact that it will tend to reduce the losses which badly prepared produce is liable to undergo during storage and transit.

7. AGRICULTURAL EDUCATION AND TRAINING

The Conference has noted with satisfaction the general progress that has been made in the development of training in agriculture for adolescents and adults and the steps which have been taken to provide for the training of staff for the requirements of Departments of Agriculture.

An exchange of views at the Conference indicated the nature of the main difficulties which are experienced in regard to vocational training for adolescents and adults under the varying conditions prevailing in the Colonial Empire.

Elementary education in certain territories still stops at an early age and consequently youths who proceed from elementary schools to agricultural courses complete their vocational training before they are ready to start agricultural enterprises on their own account. There is a decided difficulty in bridging the gap between the completion of their agricultural training courses and the time when they can establish themselves as farmers. Attention is being given to this problem in some dependencies.

The Conference is fully in accord with the general policy adopted in regard to community education and agrees that training centres for teachers and instructors should be located in rural areas wherever possible alongside those provided for forestry, veterinary, health and other subjects. Stress should be laid on the necessity for securing improvement in general living and working conditions in rural areas and efforts should be directed towards making rural life more attractive.

Supervision of students who have received vocational training is, in consequence, important and the Conference records the view that the importance of " follow-up " work cannot be over emphasized.

Definite progress in the training of subordinate staffs for Departments of Agriculture is recorded but the Conference attaches importance to steps being taken to ensure that scholars, especially those in receipt of bursaries or scholarships from public funds, admitted to vocational agricultural schools or colleges have a rural background or outlook.

The Conference welcomes the steps which are being taken by the authorities of the Imperial College of Tropical Agriculture to provide special courses of training for selected subordinate officers in Colonial Departments of Agriculture with a view to fitting them for promotion to higher staff appointments.

The Conference further welcomes a growing measure of co-operation between the agricultural and education departments, and hopes that it will become increasingly fruitful.

8. PROPAGANDA AND PUBLICITY

The Conference desires to record that close attention to propaganda and publicity is necessary if satisfactory progress in extension work is to be achieved. It has examined the different systems in operation and concludes that the use of films and, in certain dependencies, broadcasting can form a useful adjunct for reinforcing normal extension activities and of attracting attention to them.

Films, for the purposes of agricultural propaganda and instruction, may be divided into three classes :—

(a) General interest films designed to secure the interest of the audience.
(b) Background films depicting familiar local scenes and operations designed to provide a background for more detailed instruction.
(c) Films aiming at detailed instruction in agricultural processes.

The Conference notes that up to the present time experience in certain dependencies appears to indicate that, with regard to category (c), detailed

instruction in agricultural processes is better conveyed by means of still lantern pictures with a spoken commentary, but that there is need for further experiment on this point, while films under categories (*a*) and (*b*) appear to be valuable as an adjunct to detailed instruction whether by films or by slides.

The Conference considers that films under categories (*b*) and (*c*) can serve a useful purpose only if they are prepared with a precise regard to local circumstances and conditions, *i.e.*, that in general they should be prepared locally or under local guidance from technical departments. The Conference further believes that it is in general practicable for Colonial Governments to prepare reasonably satisfactory films of this nature locally without importing expensive professional assistance. The possibility of securing help from selected amateurs interested in cinematography and professional assistance when it can be obtained cheaply should not be overlooked.

In any case propaganda or publicity through the medium of the film or broadcasting requires to be "followed-up" intensively by extension workers if it is to secure a lasting measure of success and the Conference attaches importance to demonstrations and lectures at district shows, village council meetings and schools and to the organization of visits to agricultural and demonstration stations and selected farms.

THE DEVELOPMENT OF THE CASHEW-NUT INDUSTRY IN INDIA*

INTRODUCTION

MANY tropical fruits of economic importance hitherto unknown are now absorbing the attention of the grower as well as the commercial man. For instance, within a generation, the banana (*Musa* species) has passed from a rare luxury to a staple food product, the pineapple (*Ananas sativus*, Lindl.) from a little known fruit to an important one which is now sold in millions of cases of fresh and canned fruit from the Hawaiian Islands. The cashew-nut (*Anacardium occidentale*, Linn.) which is no less important than banana and pine-apple has been until recently miserably neglected as it was not deemed of much value as an article of consumption or purposes of trade. Like other forest trees, the cashew-nut tree also suffered from the axe of the foresters causing a serious national drain. With its recognition as an article of consumption as well as one yielding several by-products of economic importance which promises the development of international trade, the cashew-nut is now receiving the serious attention of the grower and the commercial man, who have begun to take up its cultivation and develop internal as well as overseas trade.

The cashew-nut received further fillip by its growing popularity in the confectionery trade of America and Europe. As a result of this, a flourishing export trade in cashew kernels has now been established on the east and west coasts of India.

The outbreak of the World War in the year 1914, however, considerably hindered the export trade of this commodity but the post-war period saw it gradually reviving and a brisk foreign demand is now reinforced.

The export trade in the cashew-nut received still further impetus by the establishment of Cochin as the chief exporting centre in South India, which draws produce from the neighbouring places of Malabar and the States of Cochin and Travancore. This present position which this commodity occupies augurs well and it is hoped that the trade for products, whose economic value has been hitherto indifferently appreciated on the east and west coasts, would further develop rapidly with other European countries besides America who is at present our chief customer.

GEOGRAPHIC DISTRIBUTION

The cashew-nut has become thoroughly acclimatized and found a congenial home in Southern India in the dense forests along the west coast. In South Kanara which is the largest producing centre in India, the cashew-nut tree

* By I. A. Sayed, B.Ag., College of Agriculture, Poona, in *Agriculture and Livestock in India*, Vol. IX., Pt. I., January, 1939.

grows very extensively in a wild state mixed with the mango (*Mangifera indica*. Linn.) and other forest trees and shrubs all along the hill slopes where, owing to the poor soil and exposed situation, it attains a low bushy form. The cashew-nut is abundant and densely scattered all over the low hilly ridges of the Goa territory where it yields a handsome revenue from the nuts and its by-products. Similarly on the east coast, it is abundant in places like Guntur, Godavari, and Vizagapatam Districts. It is also reported that Burma produces a very large quantity of raw nuts but for lack of facilities for collecting and transporting its produce is being practically wasted.

CULTURAL REQUIREMENTS

The cashew-nut is not fastidious about soil conditions in which it grows. It easily adapts itself to varying soil and water conditions without impairing its productivity. It thrives best on sandy soil in the neighbourhood of the sea. The tree is intolerant of frost. It withstands drought remarkably.

The satisfactory feature of the cashew-nut plantation is that it does not involve a heavy capital out-lay as preparatory tillage, manuring, &c., can be dispensed with. However, the tree is considerably benefitted by systematic cultivation.

The cashew-nut tree does not stand transplanting and, therefore, the seeds are sown fresh *in situ* in June spaced at fifteen feet apart. Thus 193 plants are stocked in an acre. The tree commences to bear after three years and continues for abour fifteen to twenty years although instances of trees bearing for over thirty years are not uncommon. Thereafter, the tree exudes a gummy substance and renders it unfruitful. The crop ripens in summer.

The fruit or the nut which is about one inch in length and kidney shaped develops upon the pyriform fleshy body which is three times as large as the nut. The " apple " as it is termed, assumes red and yellow colour on ripening and is formed by the enlargement of the disc and top of the peduncle. The " apple " is two inches to four inches long, almost full of juice, slightly acidic and is often used in preserves.

A fifteen to twenty year old tree yields annually on an average 150 lbs. of apples and 20 lbs. of raw nuts. This yield when commuted to money value works out as follows :—

		Rs.	A	P.
1.	150 lbs. of apples sold at 100 per anna	0	12	6
2.	20 lbs. of nuts yielding 2 lbs. of kernels sold at 2 lbs. per rupee ..	1	0	0

Income from apples is always doubtful as, at present, their utilization for the manufacture of liquor, vinegar, &c., is negligible. The income from the nuts is always certain.

PRODUCTS OF THE CASHEW-NUT

The cashew-nut tree yields several economic products but the principal ones worthy of mention are (*a*) the kernels of the nuts, (*b*) a liquor distilled

from the fermented juice of the apple, and (*c*) the oil obtained by roasting the pericarp of the nut. It is, however, regretted that with the exception of the kernels, the other two have hitherto been not exploited successfully in spite of the knowledge that in them also lies the potential source of income to the grower and revenue to the State. These products will be dealt with in the order of sequence.

(*a*) THE KERNELS OF THE CASHEW-NUT

The importance of the cashew-nut industry in India at present lies in the value of its kernels which are exported in considerably large quantities to the United States of America and to a small extent to the continent of Europe where they are utilized in the confectionary trade. The kernels are required to be shipped without shells, properly processed as they are not edible in raw state.

"PROCESSING" OR CURING OF THE CASHEW-NUT

Curing is done by roasting the nuts which causes the shells to split, thereby facilitating the removal of shells from the nuts. The roasting operation has to be done with caution as oil contained in the pericarp gives out vapours which are injurious to the human face and the eyes.

The following operations are involved in the processing of cashew-nut :—

1. *Roasting.*—The factory owners (Sayed, 1931) according to the magnitude of output, purchase raw nuts either locally or import from other parts of India and outside it. The nuts are brought to an open drying yard and spread evenly for uniform drying. On complete drying, the nuts are roasted in an open iron pan placed on a circular earthenware furnace erected three feet above the ground and fed by the cashew-nut shells. The roasting pan which is three feet long and two feet broad and has a lever and counter weight arrangement is fed with a small quantity of nuts (20 to 30 lbs.) each time and stirred vigorously by means of long iron ladles for a minute or two. A little water is sprinkled over the nuts to extinguish the fire burning the shells and are immediately thrown aside by means of simple lever adjustment. This operation is carried out by two men. The daily (six hours) output of roasted nuts amounted to 6,720 lbs. Women, not more than three, before collecting the roasted nuts for shelling, sprinkle ashes over them to dry out the oil which would otherwise cause blisters on the skin.

It may be stated here, that it has not been found possible to replace open-pan method of roasting by roasting in an oven on account of the difficulty of either the nuts remaining tough and leathery at 100°C. or kernels becoming discoloured when heated at a temperature of 120°C. (Joachim, 1936).

2. *Shelling.*—Shelling, which is invariably done by women and some times by boys who are employed on contract system, is carried out in a spacious hall specially erected for the purpose. Shelling is done with a wooden mallet. About 200 women are employed for shelling alone at a contract rate of two pice (half an anna) per pound of whole kernels. A woman working ten hours a day shells 16 to 20 lbs. of kernels, thereby earning eight to ten annas. About 25 to 30 per cent. of kernels are obtained after shelling.

3. *Peeling.*—The kernels after shelling are partially dried in a specially constructed oven to facilitate peeling of the adhering thin skin which is pinkish to reddish brown in colour. Drying of kernels, besides facilitating the removal of the inner coat, removes excess of moisture from them and thus prevents a tendency to mouldiness in storage. The oven consists of five chambers on either side partitioned by a wall with a flue at the bottom. The kernels are filled in long iron mesh trays six feet long and two feet broad which are placed in these chambers where a uniform temperature of 70°C. is maintained. At high temperature, kernels become too brittle and consequently considerable loss due to excessive splitting occurs. This process lasts for six hours when the trays are taken out and skin peeled off carefully. Peeling is done by hand. Peeling can also be effected by spreading the kernels on an open yard fully exposed to the sun. This process, however, is slow occupying nearly two days to effect complete drying. Peeling is entrusted to women and each woman peels from twelve to sixteen lbs. of kernels in a day earning on an average six to eight annas. The yield of kernels after peeling is 80 to 90 per cent.

4. *Sweating.*—The clean kernels are further subjected to an indispensable process of " sweating " to prevent splitting and breaking as only whole kernels are required for export purpose. The " sweating " receptacle consists of six chambers each containing a long rectangular shallow tank of water made of cement. The dimensions of this tank correspond with that of iron mesh trays mentioned above. The trays containing clean kernels are placed over the tank in sweating chambers for the absorption of moisture. The kernels are sweated for a period of two to three hours depending upon the atmospheric conditions and the nature of kernel. When the outside temperature is cold, trays are sweated for three hours and when hot, for two hours only.

5. *Grading.*—Kernels after sweating are graded for the foreign market according to size and quality as follows :—

1st grade	Sound and big sized kernels.
2nd grade	Sound and small sized kernels.
3rd grade	Halves and broken kernels.
4th grade	Rejects and spoilts.

The first two grades are exported to foreign markets ; the first fetching a much better price than the second. For instance, the first two grades from a factory in Vengurla (Ratnagiri District, Bombay Presidency), fetch Rs. 1,666-10-8 and Rs. 866-10-8 per ton respectively in the American market.

Grading is also done by women who have proved proficient in this process as in shelling and peeling. While grading, diseased and over-baked kernels are sorted out separately to be disposed of locally. The daily earnings of a woman working eight hours a day averages from six to eight annas for grading 55 to 69 lbs. of kernels.

The first grade kernels are white, bold, and hard. Nuts from Travancore (Paul, 1936) yield the best quality kernels while those from the North Kanara are very poor, being hard and fibrous. The yield of kernels from nuts from South Kanara and East Africa is 28 per cent. and 30 per cent. respectively.

6. *Packing.*—Packing of first and second grade kernels for the export trade is effected in tins of 25 lbs. capacity. Some factory owners also use tin-lined wooden boxes with a holding capacity of 112 lbs. of clean kernels. When using the first type of container which is cheaper than the second, packing consists of laying two ounces of oil paper at the bottom over which the above quantity of kernels are put. The top is stuffed with strips of oil paper to avoid breakage by internal movement during transit and finally the cover is hermetically soldered. The container is then exhausted which is effected by making a vent hole in the centre of the cover through which air is removed by means of an air pump. Complete exhaustion is accomplished when the pressure gauge fitted on to the pump indicates 10 lbs. pressure and immediately the vent hole is soldered. Since it is not possible to create a perfect vacuum, some packers charge the kernels with carbon dioxide gas which serves as a preservative. This practice is now discontinued as it is considered objectionable by some importers.

The kernels are now packed by exporters by what is known as the " Vita pack " process which consists of vacuumising the tins automatically and charging them with a compressed carbon dioxide gas by the control of a lever adjustment. Packing kernels by this process is accepted by the continental importers but not by the United States of America owing to the patent which the latter holds. Tins containing kernels for export to the United States of America are simply vacuumised and sealed automatically without being charged with carbon dioxide gas. Even by the latter method, kernels keep well for over two years. The " Vita pack " process can also be successfully adopted in our internal trade.

The nuts could be used in the initial stage in the same way as almonds in confectionary as top layer in cakes and fancy pastries or for chocolate or sugar coating. For successful use of kernels in confectionary in Europe, they have to be further processed before distribution to bakers and confectionary manufacturers. They must be cleaned, polished, and cut in machinery provided for the purpose into various shapes and forms to be utilized for different quality preparations. The forms now common with almonds are (1) wholes, (2) splits or halves, (3) flakes, (5) nibs, and (6) shreds.

It may be pointed out that the grades of cashew kernels imported by the London bakers and confectioners are wholes, splits, and broken tips but unfortunately these do not lend themselves easily for being converted into other required forms. Further, the chief disadvantage of the cashew kernels is that unlike almonds which are devoid of starch, they contain a good amount of it which is indifferently appreciated in the confectionary trade. This drawback is likely to impede the progress of this commodity in Europe and no wonder that it is still practically unknown in most parts over there. This means much up-hill work both for the State and the commercial men but the resources of the former and the patience and enthusiasm of the latter should ultimately overcome all obstacles and achieve the desired object of increasing national wealth through exploitation.

From the facts and figures presented in the foregoing pages, it can be asserted without a shadow of doubt that the cashew-nut industry is an important one

and, therefore, should be developed on sound scientific basis. It is gratifying to note that the cashew kernels are one of the few agricultural products in India which are properly graded and well packed for purposes of export.

The consumption of the cashew-nuts is also steadily increasing in India and it is reported that the South Kanara roasters intend to start a campaign very soon to popularize this commodity in every day use in various centres of this country. As a result of such an admirable move, it is anticipated that the demand for the cashew-nuts for local consumption would be considerably accelerated in the not too distant future. Consequently, an appreciably large quantity of supply of raw nuts would be needed to meet the increased demand. This, therefore, can be achieved by bringing under cultivation more lands specially the *varkas* areas where only the hill millets are at present grown. *Varkas* lands are unsuitable for most of the fruit crops except the cashew-nut and the mango-fruit crops of the same family. Extensive lands are available in the districts of Ratnagiri and Kanara covering an area of 17,000 and 10,000 acres respectively putting it at a very conservative estimate. The area extent is very considerable.

It may be pointed out that 20 lbs. of nuts which the cashew-nut tree yields in its present wild state is not likely to appreciably stimulate its cultivation. It is, however, certainly possible to increase this yield by systematic cultivation, paying due attention to irrigation, manuring, and selection of high-yielding plants.

It would not be appropriate to conclude this part of the subject without alluding to the future prospects of this industry. It may be mentioned with grave concern that with the rapid development of export trade, this industry is maintained by depending upon the supply of raw nuts mostly from countries like British and Portuguese East Africa. The import duty (1937) up to the year 1932 considerably checked large scale import of raw nuts from Portuguese East Africa but with the removal of import duty by Government the same year, the imports of nuts increased from 1,064,000 lbs. in 1931–32 to 29,120,000 lbs. in 1935–36. Now, knowing as they do the potential importance of this commodity, the authorities over there would take immediate steps to undertake to manufacture cashew kernels if the duty is reimposed. This threatening foreign competition is likely to paralyse the prosperity of our national industry. Under the circumstances, this industry which employs something like 100,000 workers throughout the year would be thrown out of employment for at least half the year as the factories would work on only the available local supply from the coast ports of India. This danger can be averted by imposing a light import duty or any other feasible measure.

(*b*) THE CASHEW APPLE

The cashew-nut owners, before the Abkari Act was passed, used to distil an agreeable liquor from the cashew apple and used it for diuretic purposes. Locally the ripe fruits are eaten mixed with salt or the juice is extracted and fermented with sugar for the preparation of vinegar. Until as recently as this year, liquor was not distilled anywhere in the British territory of South India except in the Portuguese territory and the Sawantwadi State.

The suitability of the cashew apple in the distillation of liquor can be ascertained at a glance from the composition (1922) of the cashew apple juice mentioned below :—

	Per cent.
Acidity in grammes of sulphuric acid	0·28
Reducing sugar	11·96
Non-reducing sugar	0·66
Total sugars	12·62

Besides, the juice is rich in pectin contents.

DISTILLATION OF LIQUOR FROM THE CASHEW APPLE

To extract juice, ripe apples (Sayed, 1931) are crushed under feet in wooden vessels or stone vats which give nearly 62 per cent. extraction. The juice is strained through a coarse cloth to remove foreign matter and coarse material and stored in large copper vessels for fermentation for seven days. The fermented juice is poured in another copper vessel of forty gallons capacity. A pipe four inches in diameter is soldered to this vessel which communicates with another brass vessel. The first one is mounted on a low circular furnace made of earth which is fed by the dry cashew-nut leaves. As the juice is heated, the vapours travel through the communicating pipe and are liquified in the second vessel by pouring cold water over it. This operation is carried out by two men. The distillation process is discontinued when the distilled liquor is one-third the capacity of the first vessel. This is ascertained merely by tapping the vessel which is a matter of experience. The distilled liquor is then poured into earthen vessels and is allowed to stand for twenty-four hours when it is finally stored in stock barrels of capacities ranging from 268 to 619 gallons. Forty gallons of apple juice yield eight gallons of distilled liquor. The distilled liquor is perfectly clear like water. Distillers sometimes purchase apple juice from outside at the rate varying from two and half to three annas for four gallons. The liquor is sold at Re. 1- 8- 0 per gallon.

The cashew liquor is manufactured in the Sawantwadi State, Goa, and Malwan (Ratnagiri District). The quantity of cashew liquor manufactured in Goa is as follows :—

Year.	20 per cent. water Gallons	25 per cent. water Gallons	60 per cent. water Gallons
1930 ..	448 ..	8,560 ..	163,309
1931 ..	269 ..	10,358 ..	163,230
1932 ..	188 ..	8,935 ..	138,145

It is surprising that this industry has not received its due encouragement which it deserves although, as it is obvious, it would have been an additional source of revenue to the State. As said elsewhere, the distillation of liquor is restricted to a few remote localities. Therefore, as a measure of experiment, the State may start one or two distilleries in the South Kanara Districts to ascertain how far cashew liquor can be economically prepared or else, only a few prospective distillers may be permitted to manufacture this liquor. It is believed that the cashew liquor will have a popular demand from the local people on account of its recognized medicinal properties and because it would be available very cheap.

(c) PERICARP OIL

The hard shells of the cashew-nut yield oil which on exposure turns black quickly and is known as cashew oil, cardoil, or cardol. This oil is considered to be a corrosive poison like crude carbolic acid and is required to be used with caution. The chief constituents of the pericarp oil are anacardic acid, gallic acid, and cardol (Joachim, 1936). The oil is reddish brown in colour.

The production of the cashew-nut oil has increased appreciably in recent years owing to large scale export of cashew kernels to the United States of America and other European countries. It is estimated (Patel and Patel, 1936) that about 71,480,000 lbs. of raw nuts are annually decorticated in India. The quantity of shells available for extraction is 29,120,000 lbs. which would yield 53,000 gallons of oil.

The shells of the nut by the present manufacturing process yield only 12 to 15 per cent. oil although they contain 35 per cent. oil. A bottle of cashew oil fetches one and a half anna or Re. 1-4-0 a gallon.

The oil is largely used by fishermen to tan their nets. It is also effectively utilized in preventing white ants attack when painted on furniture, stationery, &c. The oil has also been recommended as an external application for leprosy as it is considered to be a specific remedy for it and also for ringworms and corns.

OTHER USES OF THE CASHEW-NUT TREE

1. Locally green cashew-nuts are cut open with a knife and the unripe kernels are used either as spiced vegetables or boiled with sugar syrup to make a sweet dish. The green kernels do not keep long and like green vegetables have to be used rapidly.

2. The unpeeled cashew kernels form a good poultry food. The nutritive value of the kernels is also high as can be seen from the following analyses (Joachim, 1936).

	Per cent.
Water	8·1
Protein	7·6
Fat	12·3
Carbohydrates	59·2
Fibre	11·0
Ash	1·8

The kernels make a good candy when mixed with cocoa.

3. The tree yields a gum and the chief characteristic feature of it is that it possesses insecticidal properties and helps to ward off the attacks of insects. The gum is soluble in water and is often used in book binding in this country.

The tree also yields a useful timber which is commonly utilized in boat making and occasionally for making packing cases. It can be converted into charcoal.

4. The cashew leaves serve the double purpose of tooth powder and tooth brush and the users, it is said, retain their teeth to a ripe old age ; the acid contained in the leaves acting as the toning agent of the gums. The bark is used in the preparation of effective mouth wash and the root is used as a purgative.

5. The kernels contain 40 to 50 per cent. oil which is light yellow in colour and sweet in taste. It is non-drying and can be used as food oil, provided it is carefully prepared. The residual cake after the oil is expressed is rich in albuminoids (Ludowyk, 1927).

6. The apple juice is rich in pectin and can be utilized in the preparation of preserves. The fruit is juicy and contains 65 per cent. juice of the weight of fruit. This juice when mixed with iron sulphate makes an excellent hair dye (Galang & Lazo, 1936).

SUMMARY AND SUGGESTIONS

The importance of the cashew-nut industry as an Empire product needs no emphasis as the export figures as well as growing internal demand bear testimony to its justification. That the cashew-nut forms a very suitable and cheaper substitute for almond in confectionary and bakery trades is so well recognized by the United States of America that it made rapid strides in exploiting the import of this commodity and is now importing annually enormous quantities of the shelled nuts and clean kernels. Further, its demand is steadily increasing on the continent and in India.

The utilization of the cashew apple in the distillation of an agreeable liquor which is so much esteemed by the local people gives an indication that three people, *viz.*, the grower, the distiller, and the State are going to be considerably benefitted by this industry. This would mean total prevention of loss of ripe fruits which now occurs in large quantities. The future of this industry, therefore, rests entirely with the industrialist and the State. The instance of the Portuguese Government manufacturing liquor from the cashew apple from which they derive a rich revenue should infuse sufficient interest among the industrialist and the State to promote this indigenous industry at a very early date.

It may be concluded with modest optimism from the survey of facts and figures set down in these pages that the cashew-nut industry and the industries subsidiary to it have got a bright future and with proper exploitation through publicity and propaganda both by the State and those of the public interested in it, they would constitute a great advance in the promotion of the indigenous industry and consequently augment national wealth. In this connection the following suggestions are offered which it is believed would be of material use in the exploitation and advancement of the cashew-nut industry :—

1. Immediate measures may be adopted to exploit the market of our Empire product as a source of national wealth by allotting a special grant for publicity and propaganda.

2. Attempts may be made to evolve mechanical devices for roasting, shelling, &c., so as to overcome foreign competition.

3. To meet the increasing foreign and local demand, more lands may be brought under cultivation with a view to lessen the import of raw nuts from foreign countries and scientific methods of cultivation adopted to increase the yield of the cashew-nut trees.

The cultivation of the trees is not very difficult and, therefore, it will be easy for the Agricultural Department to achieve this object by intensive propaganda. It is, however, not possible for the Forest Department to undertake the cashew-nut tree plantations on a large scale as the main object of that Department is to plant timber-yielding species.

4. The cultivation of the cashew-nut tree may be extended and popularized by educating the private owners of *varkas* lands to its importance and value in the field of trade and impressing upon them the evils of indiscriminate felling of these trees for the purpose of fuel.

5. The State may consider the advisability of disposing *varkas* lands to persons interested in the cultivation of cashew-nuts on easy terms of payment to enable large plantations being established for promoting its cultivation as a money crop.

6. The industrial and economic interest of the grower and manufacturer should be safeguarded from foreign competition by appropriate legislative measures. This object can also be achieved by encouraging the establishment of a few more factories with a view to minimise import of raw nuts and thus accelerate export trade.

7. It would be desirable if the Provincial Governments negotiate with the railway and shipping companies and urge the necessity of reducing freights on cashew-nuts.

8. Investigations with regard to transporting, drying, and storage of cashew apples may be undertaken. Production of alcohol from dried apples also needs thorough investigation.

9. If at present Government do not consider it feasible to start distilleries, permission may be granted to a few private individuals to do so and the excise duty charged on the output which would mean an additional revenue to the State.

SOIL NUTRITION*

WE venture to suggest that a new branch of soil science be recognized, namely, soil nutrition. Soil nutrition would be related to general pedology in much the same way as plant nutrition is to botany or animal nutrition to zoology. At present we speak of supplying nutrients to the soil when we mean supplying nutrients to the plants that grow on the soil. A clearer distinction could be made between soil nutrition and plant nutrition—a distinction which might relieve the soil chemist from spending so much of his time on what is essentially the plant physiologist's job and enable him to pay closer attention to the soil.

It must be emphasized that the term nutrition, as applied to the soil, is used in an analogous sense to plant and animal nutrition, for want of a better word. A properly fed plant is in a condition to manufacture animal foods in which plant nutrients play a quantitatively subordinate part. By analogy, a properly fed soil is one which is in a condition to manufacture plant nutrients in a form in which they are available for plant growth. Most soils possess an almost limitless supply of the major and minor plant nutrients (and toxins) and, when properly nourished, give them up to, or withhold them from, the vegetation in the quantities required for normal plant growth. The mechanism of this remarkable process should be the subject of the soil nutrionist's study. Soil nutrition may not be of much practical importance in agriculture, where plant nutrition is becoming increasingly independent of the soil, but it is fundamental to the science of the soil. Agriculture tends to regard soil as a somewhat inefficient substitute for sand or water as a medium for conveying nutrients to the plant, but where the hand of man is absent plant growth depends primarily upon the processes of soil nutrition, as much as the welfare of the animal world depends ultimately upon plant nutrition. Soil nutrition may thus be regarded as a fundamental process in the cycle of life and worthy of the closest scientific study apart from any practical advantages that might accrue from such study.

The study might start by a consideration of soils showing obvious symptoms of malnutrition. Malnutrition is not necessarily indicated when a soil responds readily to ordinary manurial dressings, since such response may be due merely to the abnormal demands of a heavy crop being met by the applied nutrients, and may have nothing to do with the ability of the soil to render its own supply of plant nutrients available. Malnutrition shows itself rather when some physical or chemical treatment produces an increase in vegetal production out of all proportion to the amount of plant nutrients—if any—applied. Such a disproportionate increase implies that the production of available nutrients *by the soil* has been stimulated by treatment.

* Reproduced from *Soils and Fertilizers*. vol. 1., No. 5, 1938, pages 181–183, issued by the Imperial Bureau of Soil Science.

Simple cases of feeding ill-nourished soils are exemplified by drainage and cultivations which, *per se*, produce increased yields. The ways in which such operations feed the soil are believed to be known, but there are certain other cases of malnutrition which the soil chemist finds difficulty in explaining according to orthodox plant-nutrition theory. Some of these cases are capable of quite simple explanation, others demand the exercise of imagination. A few examples may be given.

Cultivated crops in the tropics sometimes respond readily to organic manures where artificials are without effect. It has been suggested that the readily available artificials " burn " the crops, while the organically combined nutrients are released more gradually. A particular case is illustrated by the remarkable response obtained to small dressings of farmyard manure (2 tons per acre) in Nigeria, where complete artificial-fertilizer treatment was ineffective. The extra nutrient uptake in the manured plants was greater than the amount supplied by the manure. Later work has shown that much the same response is obtained by applying superphosphate in the absence of nitrogen and potash.

Large yield increases have also been obtained in South Russia by applying enormous quantities of superphosphate to lateritic soils, although there was little or no recovery of added phosphate in the crop. Here the phosphate may act by precipitating toxic aluminium in the soil.

A somewhat analogous abnormal response to phosphate has frequently been observed in young conifer plantations on acid peats where growth may be 5–10 times as vigorous on slagged plots as on controls. Under these conditions other artificial fertilizers (including superphosphates) are without effect or are deleterious.

M. C. Rayner has obtained remarkable results by using specially prepared composts, poor in nutrients, with conifer seedlings on strongly podzolized soils. The treated plants throve better than similar plants grown in fertile nursery soil, whereas the controls failed entirely. The composts, moreover, had no effect except when applied to very poor soils, in fact they sometimes depressed growth on good soils. There can be no doubt but that something other than a direct plant-nutrient effect is involved here. Dr. Rayner attributes her results partly to a stimulation of the mycorrhizal habit in the trees by the composts and, more generally, to a " change of direction of the biological activities responsible for humus decomposition ". The origin of the compost material has a very marked influence on the efficacy of the product. Basic slag on these mineral soils has also a considerable effect which is not readily explained on the same grounds as the compost effect.

Dhar, in India, has made alkaline soils productive by applying molasses, poor in plant nutrients. The decomposition products of the molasses presumably neutralize soil alkalinity besides stimulating micro-biological activity.

In all these cases plants on the treated or " fed " soils took up more nutrients in comparison with the controls, than could be accounted for in the nutrients applied, that is, the soil was put into a condition where it could feed the plants from its own reserves. This is a soil's natural and primary function. When it performs that function it is healthy ; when it is merely a temporary receptacle

for added plant nutrients and cannot itself feed a crop it is unhealthy, even though it may yield a profit to fertilizing. The medical profession has latterly decided that the study of health— if time can be found for it— is just as important as getting sick people back to a workable condition, and the pedological profession—if it could find time—might equally pay attention to discovering what a soil requires for normal functioning as well as to making fertilizers give their maximum return when applied to the soil.

Numerous facts are already available with regard to soil health but they have been considered more in relation to their bearing on plant than on soil nutrition. The physico-chemical condition of the soil is obviously of first importance, and possibly the main function of soil nutrients is to maintain a regulated series of precipitation and solution reactions in the soil mass. There is nothing very novel about the concept of soil nutrition ; the advantage of treating it as a distinct branch of pedology would be that, apart from drawing the pedologist's attention to the soil, it might bring into their proper relationship such apparently diverse phenomena as the failures of pine transplants on acid heaths and of farm crops in the topics. They may have the same kind of relationship to one another as two such dissimilar phenomena as, *e.g.*, potash-deficiency symptoms in bananas and in sugar-beet. Certain effects of minor elements in the soil may admit of more plausible explanation as soil-nutrition than as plant nutrition phenomena.

The examples of soil malnutrition cited above suggest that phosphate may be just as important a soil nutrient as it is a plant nutrient, and that the phosphate requirement of a soil may have a more literal meaning than that usually given to it. Lime requirement is certainly more a soil-nutrition than a plant-nutrition term. Nitrogen is obviously a soil nutrient, but in organic combination and not as ammonium or nitrate. We cannot think of any evidence that potash is an essential soil nutrient. The claims of other commonly occurring constituents such as silica, iron and aluminium as soil nutrients deserve consideration. Humus may—almost certainly does—contain soil nutrients other than nitrogen and phosphorus, but what these are and how they function is unknown. A knowledge of the basic principles of soil nutrition should go far towards elucidating the chemistry of humus. It should also enable us to correlate the working of the various " cycles "—of weathering, organic matter, vegetation, micro-organisms, &c.—and to obtain a clearer picture of the intricate internal mechanism of soil.

THE SETTLEMENT OF EDUCATED MEN ON THE LAND*

IN his "Report on the Work of the Imperial Council of Agricultural Research in Applying Science to Crop Production in India", Sir John Russell has referred to the great gap which exists between what could be accomplished by the cultivator in India if he were to utilize fully the knowledge available as a result of agricultural research and what is actually being done by him. For instance, by adopting better methods of cultivation, using improved varieties of seed and protecting their crops from the ravages of diseases and pests, agricultural experimental stations obtain, in the case of most crops, yields vastly greater than those obtained by the average cultivator. But, although such advantages can be gained by utilizing present knowledge, the cultivator still continues largely to follow his old methods and adopts the achievements of research only to a limited extent. The great need, therefore, of the present time is to take adequate steps to ensure their wider and fuller adoption.

Sir John considers that one of the greatest handicaps under which Indian agriculture labours in this connection is the absence of an educated agricultural middle class in the village and he contrasts the position here with that in Western countries where he attributes many of the great advances, which have been made, to the shrewdness, and progressive ideas of men of this type. In view of this conclusion, it will be of interest to consider some practical steps which are being taken at present in India to settle educated young men on the land.

Efforts have been made on a small scale in recent years in Mysore and Travancore to place on the land young men who had first obtained some training at an agricultural school. In the former case, progress appears to be slow so far, whilst in the latter, twenty-four trained boys have been placed on holdings of ten acres each. It is a condition of tenancy that students must live on the land and farm it under the guidance and supervision of officers of the Agricultural Department. A loan up to Rs. 500 is also granted to the student tenant, where required, for the purchase of seeds, manure, implements, &c., and after repayment in full, if all the conditions of the lease have been observed satisfactorily, the land is permanently assigned to him.

By far the largest experiment so far made in placing educated men on the land, is being carried out in the Punjab, where an experimental scheme was started in 1932. In that year, two villages situated in one of the canal irrigated tracts were colonized entirely by forty-eight educated youths, consisting of forty-four graduates and under-graduates of Arts and Science colleges and

* Editorial article in *Agriculture and Livestock in India*, Vol. VIII., Part VI., November, 1938.

four graduates in Agriculture. Each grantee was allotted two squares (fifty-five acres) of canal irrigated land. The principal conditions attached to the lease are :—

(1) The tenant must live permanently on the land and must build on it a residential house to the satisfaction of the local Collector,

(2) The tenant must cultivate the whole of his land with his own hands but he is allowed to employ paid labour to assist him in doing so,

(3) After the expiration of five years, if all the conditions have been observed satisfactorily, the tenant is granted occupancy rights, but he does not obtain proprietory rights,

(4) The tenancies are subject to the rule of primogeniture, but if a tenant dies without having acquired occupancy rights, the tenancy lapses to Government.

During the first two harvests after the commencement of the tenancy Government remitted the whole demand on account of land revenue, *malikana*, occupiers rates and cesses.

In the same year (1932) a considerable number of Agricultural Assistants, many of them possessing some years' experience of departmental work, was brought under reduction, due to financial stringency, and the Punjab Government allotted them similar grants on similar conditions. In this case, however, the grantees were not located in villages set apart for themselves but were scattered in pairs in old colonized villages, where it is expected that by the adoption of the modern methods of farming which they had learnt and which they had been demonstrating to cultivators previously, they will serve as examples for the ordinary cultivators surrounding them of what could be achieved by farming on modern lines.

Again, in 1937, two more villages in canal irrigated areas were completely colonized by forty-one more literate grantees. They consisted of eleven graduates and certificate holders in Agriculture and thirty graduates or undergraduates from Arts and Science colleges. Finally, in the same year also, thirty-eight graduates and certificate holders in Agriculture were allotted similar grants and, as in the case of the retrenched Agricultural Assistants, were scattered in pairs throughout the older villages.

At present, therefore, 8,910 acres of land in the Punjab have been colonized by 162 educated young men, of whom eighty-nine are the sole cultivators in four villages and the remainder are scattered, usually in pairs, in the older villages. The experiment must continue further before any final conclusions can be reached as to its success or otherwise. A recent visit to some of the grants, however, indicated that ultimate success or failure is likely to depend very greatly on the individuals concerned. There is no doubt whatever that those lessees, who have had an agricultural education, are in a much better position to make a success of their grants than those from Arts and Science colleges and yet some men of the latter class, who have had the foresight to copy the methods employed by their agriculturally trained co-villagers, are producing results which compare very favourably with those of the latter. Even amongst themselves the agriculturally trained graduates vary in their

achievements, depending on the extent to which they are prepared to work and to apply the training which they have received. Some of them have been outstandingly successful and in some cases they have actually obtained yields of wheat and cotton which are almost a record and which compare very favourably with the best results which have so far been obtained on agricultural experimental stations in the province.

The further progress of this experiment will be watched with considerable interest not only in the Punjab itself but throughout India.

MEETINGS, CONFERENCES, &c.

RUBBER RESEARCH SCHEME (CEYLON)

DRAFT MINUTES OF THE FORTY-SIXTH MEETING OF THE RUBBER RESEARCH BOARD HELD IN THE COMMITTEE ROOM OF THE CEYLON CHAMBER OF COMMERCE, COLOMBO, AT 2.30 P.M. ON TUESDAY, JANUARY 17, 1939

Present.—Mr. F. P. Jepson, Acting Director of Agriculture (in the chair); Mr. C. H. Collins, C.C.S. (Deputy Financial Secretary); Mr. I. L. Cameron; Mr. L. M. M. Dias; Mr. L. B. de Mel, J.P., U.P.M.; Mr. G. E. de Silva, M.S.C.; Mr. L. P. Gapp; Mr. F. H. Griffith, M.S.C.; Col. T. G. Jayewardene, V.D.; Mr. R. C. Kannangara, M.S.C.; Mr. J. C. Kelly; Mr. F. A. Obeyesekere; Mr. J. L. D. Peiris; Mr. B. M. Selwyn; Mr. E. W. Whitelaw.

Mr. T. E. H. O'Brien, Director, was present by invitation.

Before proceeding with the agenda the Chairman said he wished to report that he had assumed duties as Chairman of the Board with effect from December 1, 1938, while acting as Director of Agriculture in the absence of Mr. E. Rodrigo, who was on leave. Mr. Rodrigo was expected to resume duties on March 1, 1939.

Reported that messages of good wishes for 1939 had been received from the Rubber Growers' Association, the Rubber Research Institute of Malaya, and the Ceylon Association in London.

1. Minutes.—

Draft minutes of the forty-fifth meeting which had been circulated to members were confirmed and signed by the Chairman.

2. Board.—

Reported the following changes in the membership of the Board since the last meeting:—

(1) Mr. E. W. Whitelaw's three year period of office had expired on December 14, 1938, and he had been re-nominated by the Rubber Growers' Association to serve for a further period of three years from that date.

(2) Mr. R. P. Gaddum had resigned with effect from January 10, 1939.

(3) Mr. J. C. Kelly had resumed membership on return to the island with effect from December 6, 1938, relieving Mr. R. A. Sharrocks, who had acted for him.

Votes of thanks were passed for the services of Messrs. Gaddum and Sharrocks.

3. Accounts.—

(a) *Statement of Receipts and Payments of the Board* for the quarter ended September 30, 1938 (C.P. 727) was approved.

(*b*) *Dartonfield and Nivitigalakele accounts* for July, August, September and October, 1938, were tabled.

(*c*) *Depreciation rates.*—Reported that, as decided at the last meeting, the advice of the Treasury representative had been sought regarding amendment of the allowances to be made for depreciation of fixed assets. After consideration of the recommendations made by the Treasury representative the following rates were approved :—

	New Rate.	Old Rate.
Buildings	$3\frac{1}{2}\%$ ..	4 %
Plant and Machinery	$7\frac{1}{2}\%$ ..	$7\frac{1}{2}\%$
Lab. Equipment	$7\frac{1}{2}\%$ ..	25 %
Electric accumulators	20 % ..	$7\frac{1}{2}\%$

(*d*) *Fixed deposit.*—Reported that a fixed deposit of Rs. 50,000 had been renewed for a further period of 12 months from December 31, 1938.

(*e*) *Investment of Funds.*—The following Committee was appointed to consider the question of future investment of funds and report to the Board :—

The Chairman of the Board, The Treasury representative, Mr. J. C. Kelly. and Col. T. G. Jayewardene, V.D.

(*f*) *Employees' Provident Fund.*—Consideration was given to a proposal to modify the rules of the employees' provident fund so that all monthly paid employees would become eligible for membership. After discussion it was decided to refer the matter to the Committee appointed to consider the investment of funds.

4. Staff.—

(*a*) Reported that Dr. L. A. Whelan, M.Sc. (N. Z.), Ph.D. (Aberdeen), A.I.C., the newly appointed Soil Chemist, had arrived in Ceylon on October 31, 1938.

(*b*) Reported that Mr. M. W Philpott, Chemist, had returned from leave on November 14.

(*c*) Reported that Mr. P. Tharmalingam, B.Sc., had been appointed Analyst in the Soils Department with effect from January 3, 1939, in accordance with the decision reached by circulation of papers.

5. Experimental Committee.—

Recommendations made at a meeting held on December 19, 1938.

(*a*) *Over-expenditure of votes.*—Supplementary votes of Rs. 87 and Rs. 40 were approved to meet over-expenditure in replanted areas No. 2*a* and 3, at Dartonfield Estate.

(*b*) *Training in estate works.*—Arising from an application for training in general field works consideration was given to the possibility of facilities being given for such training at Dartonfield and Nivitigalakele. After discussoin the Director was asked to submit proposals to the Experimental Committee for consideration.

(*c*) *Identification of clones.*—Reported that the Chinese Mandor, who had been engaged in the identification of clones on estates, would return to Malava on February 9. It was agreed that the services of Research Scheme officers should be made available for this work in future, subject to their travelling expenses being refunded by the estates concerned.

6. **Technical Officers Progress Reports for the Quarter ended September 30, 1938,** were adopted without comment.—

A copy of notes prepared by Mr. Philpott dealing with visits to factories, &c., and interviews while on leave in England was tabled. It was agreed that one copy of the notes be circulated to members.

7. **London Advisory Committee.**—

Minutes of meetings of the London Advisory Committee for Rubber Research (Ceylon and Malaya) and the Technical Sub-Committee held on September 30 and October 14, 1938, respectively were adopted.

8. **New Rubber Planting.**—

Reported that Government had adopted a scheme for giving advice and assistance to persons of the middle and peasant classes in the planting of Rubber under the terms of the Rubber New Planting Ordinance, No. 38 of 1938. An officer of the Department of Agriculture had been seconded for duties as Chief Advisory Officer in the Land Commissioner's Department and would have a staff of about 50 instructors.

As part of the arrangements, the Research Scheme had been requested to prepare a manual of instruction in new planting. The work had been undertaken by Mr. R. K. S. Murray, who had completed the draft of part I, dealing with first year planting operations.

It was also desired by Government that the instructors should be trained at Nivitigalakele. The time available was very short and it was proposed that the instructors should be taken in four batches for a period of 2 weeks training in contour lining, cutting of drains, &c. The Smallholdings Propaganda Officer would be in charge of the work. The proposal was approved.

9. **Rubber Conferences.**—

Reported that the Rubber Conference held at Tebuwana, on November 25, 1938, under the auspices of the Planters' Association of Ceylon and with the co-operation of the Research Scheme, had been very successful. It was agreed that future Conferences should be organized on similar lines and that the Research Scheme would co-operate fully with the Planters' Association in the matter.

The meeting terminated with a vote of thanks to the Chamber of Commerce for the use of the Committee Room.

Research Laboratories,
Dartonfield,
Agalawatta.

February 2, 1939.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD IN THE COMMITTEE ROOM OF THE CEYLON CHAMBER OF COMMERCE ON THURSDAY, DECEMBER 22, 1938, AT 2.30 P.M.

Present—Mr. James Forbes, Jnr. (Chairman); The Hon. the Financial Secretary (Mr. H. J. Huxham); The Acting Director of Agriculture (Mr. F. P. Jepson); The Chairman, Planters' Association of Ceylon (Mr. R. C. Scott); The Chairman, Ceylon Estates Proprietary Association (Mr. R. J. Hartley); Major J. W. Oldfield, C.M.G., O.B.E., M.C.; Mr. I. L. Cameron; Mr. J. D. Hoare; Mr. J. C. Kelly; Mr. T. B. Panabokke, and Dr. R. V. Norris (Director and Secretary). Messrs. H. Tonks (Visiting Agent) and J. A. Rogers (Superintendent) were present by invitation.

Absent.—Mr. R. G. Coombe and Mr. S. F. H. Perera.

1. The Notice convening the meeting was read.

A letter was tabled from Mr. R. G. Coombe, expressing regret at inability to attend.

2. The Minutes of the Meeting of the Board held on October 28, 1938, were confirmed.

3. Membership of the Board and Committees.—

Reported that Mr. J. C. Kelly, had resumed his seat on the Board on his return from leave, relieving Mr. K. W. Taylor.

A vote of thanks to Mr. Taylor for his services was recorded.

The Chairman welcomed Mr. F. P. Jepson, who was acting Director of Agriculture in place of Mr. E. Rodrigo, who had gone on leave.

4. Finance.—

(*a*) The Institute's Accounts to November 30, 1938, were approved without comment.

(*b*) *Adjustments of Votes.*—Various adjustments of sub-votes sanctioned by the Chairman under Rule 19(*e*) were confirmed by the Board.

The following additional votes were approved :—

Research Revenue Account.—

General Services.—Vote 57, Water Supply Rs. 350.
Miscellaneous.—Vote 71, Medical Scheme Junior Staff, Rs. 70.
Vote 72, Medical Fees Sub-staff, Rs. 140.

Estate Working Account.—

Vote 63, Machinery upkeep, Rs. 275.
Vote 22, Watchers, Rs. 175.

(*c*) *Investments*.—Reported that the Seal of the Board had been affixed to the transfer certificates and Interest notices relating to the recent purchase of 4 per cent. Funding Loan as sanctioned by the Board at the last meeting.

(*d*) *T.R.I. Cess*.—Reported that the Ordinance to provide for the continuance of the Cess at 14 cents per 100 lb. tea exported until December 31, 1943, was passed by the State Council without division on December 14, 1939.

The Chairman expressed his indebtedness to the Financial Secretary, Major Oldfield and Mr. Gaddum for their assistance in this matter.

(*e*) *Estimates 1939*.—The Chairman said these had been circulated to the Board and had been before the Finance Sub-Committee that morning.

A. *Working Account*.

It was noted that the estimates were based on a crop of 185,000 lb. a check roll average of 54 cents, and a plucking average of 45 cents.

The Board approved that General Charges be divided between Working Account and Capital in the proportion of 83½ per cent. to Working Account and 16½ per cent. to Capital.

The Board then approved the estimate for estate working account amounting to Rs. 93,870 or 50·75 cents per pound.

B. *Estate Capital Account*.

In reply to the Financial Secretary who referred to the cost of bringing immature areas into bearing, the Chairman explained that the proportion of General Charges debitable to Capital would be reduced in the following year. Figures would then be prepared giving the cost of clearings.

The Estimate for Estate Capital Expenditure amounting to Rs. 15,371 was approved.

Research Revenue Expenditure.—It was noted that provision was made under Votes 2 and 39 for the Chairman and Director to visit N. E. India and the Tocklai Experimental Station during the year.

The Board approved the estimate of Rs. 240,528 under Research Revenue Account.

The Board approved the revised estimate of Rs. 15,875 under Research Capital Account.

The Board also sanctioned the carrying forward to 1939 account of any unexpended balance of the votes for the Guest House and Equipment.

5. St. Coombs Estate.—

The Chairman said the Visiting Agent's Report for December had only just been received and would come before the Board at the next meeting after consideration by the Experimental Committee.

6. Rules for Guest House.—

The Board considered the draft rules for the use of the Guest House as recommended by the Finance Committee. After minor modifications in wording, the Board approved these rules with the addition of a rule relating to recoveries for breakages.

In reply to Mr. Hoare, the Chairman said a Guest House account would be maintained.

He also informed the Board that the Guest House should be ready for occupation in February.

7. T. R. I. Conference.—

The Board approved the date of the Conference being changed to February 13 and 14 to enable Sir John Russell, F.R.S., to attend.

It was also agreed to hold the meeting on the 13th at the D.A. and C.C., Radella.

The draft programme for the Conference was approved.

8. Research on Chemistry of Tea.—

The Director reported that information had been received from the Ceylon Association in London that the N.E.I. Authorities had agreed to contribute to the Joint Research Fund for 5 years. It was hoped a contribution would also be obtained from the South Indian Tea Association.

Mr. Lamb was in touch with Dr. Lampitt in regard to the technical aspects of the scheme.

9. Any other Business.—

(i.) The Board approved of the Director accepting an invitation to broadcast to Schools on March 9, on the work of the Institute.

(ii.) A vote of thanks was accorded to the Ceylon Chamber of Commerce for the use of their room for meetings of the Board.

The Meeting then terminated with a vote of thanks to the Chair.

Roland V. Norris,
Secretary.

January 6, 1939.

REVIEW

International Bibliography of Agricultural Economics.—A new quarterly publication of the International Institute of Agriculture in Rome. Subscription 6*s*. 6*d*. per annum.

THE International Institute of Agriculture in Rome has now begun to publish a current bibliography, at quarterly intervals, which deals with agricultural economics in all its various phases. This bibliography, which is based on the material received by the Library of the Institute, is compiled under the technical direction of the Librarian, Dr. S. von Frauendorfer.

The International Bibliography of Agricultural Economics covers the economic and social aspects of agriculture, such as agricultural economics, agricultural policy, settlement, credit, co-operation, insurance, marketing, prices, statistics, farm organization and management, valuation, labour, accounting, rural sociology, agricultural history and geography, legislation and education and all other agricultural problems, in so far as they are considered from the economic and social point of view. Only publications of purely technical character are excluded. Titles of all publications, whether books, bulletins, pamphlets or articles in periodicals, are indicated, including all bibliographical details required for proper identification. All languages receive equal treatment and titles in the less known languages are provided with a translation.

The bibliography, which is the only one which covers systematically the world literature on agricultural economics, is carefully classified by subjects. An author-index will be supplied at the end of each volume. The annual subscription, postage included, is 6*s*. 6*d*. or $1,60.

Les Sols de l'Afrique Centrale, Specialement du Congo Belge.—The Soils of Central Africa, especially of the Belgian Congo. Volume I, The Lower Congo. By J. Baeyens. Publications of the National Institute for the Agronomic Study of the Belgian Congo, 1938. Price 150 Fr.

THIS great work by Prof. Baeyens on the Soils of the Lower Congo is the first of a series on the soils of Central Africa, particularly of the Belgian Congo. As a treatise on the soils of a particular tropical region, it will rank with, if not excel, that of Mohr's *Tropical Soil Forming Processes in Java and Sumatra*. It is therefore not surprising that the book has won for the author the much coveted Barman Prize, awarded in Belgium for the best work of the year on any subject connected with scientific research in the Colonies. It is written in French but contains summaries in English and German at the end of each chapter.

Sir John Russell, the Director of Rothamsted Station, in a preface to the book comments on it thus : " Not only has he (the author) presented, in regard to the knowledge of these soils, points of view which merit the gratitude of his colleagues in all tropical countries of the world, but he has been able to establish a fertility scale based on analytical data which will be useful to planters and to officers charged with finding new possibilities for tropical crops."

The book is divided into two parts. The first deals with the general pedological properties of the soils of the Lower Congo consisting of nine chapters on such subjects as " factors of fertility", " importance of the profile study", " mechanical properties and the structure", " chemical and colloidal properties", &c., of the soils of the Lower Congo. In the second section of the book, the soils are examined from the standpoint of their natural agricultural properties, and classified on a pedological scale of fertility in respect of the different tropical crops of major importance grown in the Lower Congo. The nine chapters which constitute this section deal with principles applied in the construction of a pedological scale of fertility for the soils of Lower Congo, sugar, cacao, coffee, rubber and oil palm plantations, pedological characteristics and agricultural value of the soils of Lower Congo and examples of pedological studies of certain virgin soils with a view to determining probable fertility. This part of the book is extremely helpful to soil workers in tropical countries who, like the reviewer, are entrusted with the responsible task of surveying the crop suitabilities of undeveloped areas in their respective countries, often under disadvantageous and difficult conditions. The book will repay the careful study of every tropical soil worker as it furnishes numerous examples of the practical application of the results of modern field and laboratory soil studies to tropical crops.

The book is profusely illustrated with photographs, diagrams and maps, is replete with tables, both in the text and appendices, and contains an extremely comprehensive bibliography of books and publications relating to the subjects discussed.

No research institution, in the tropics particularly, can afford to be without this book which, while it may not deal specifically with all the important tropical crops, opens up new vistas for profitable soil research and investigation in these regions of the world.—A. W. R. J.

Plant Injection for Diagnostic and Curative Purposes.—By W. A. Roach. Imperial Bureau of Horticulture and Plantation Crops. Technical Communication No. 10. 5*s*.

DR. Roach, in publishing his monograph on plant injection methods for diagnostic and curative purposes, has placed the horticulturist, the plant physiologist, the plant biochemist, and all those interested in the subject of deficiency diseases under a debt of gratitude to him, for he has brought order out of chaos in a field of work which, undertaken on correct lines, offers great academic and economic possibilities. In this publication, the author first traces the history of plant injection from the earliest times to the present day, indicating, in particular, the results of recent investigations on the subject. He then details the different injection methods devised by him, and the results achieved by their adoption on material ranging from the leaf of a strawberry plant to fully grown orchard trees such as apples and plums with such clarity and detail that even the inexperienced experimenter cannot fail to avoid the numerous pitfalls which would otherwise beset his path. The usefulness of the section on injection methods is enchanced by the inclusion of certain methods of other workers, *e.g.*, Leach's shoot injection method. Solid injection is not dealt with in any detail.

In his general discussion of the application of plant injection methods and throughout the monograph, Dr. Roach quotes a number of instances where the adoption of these methods has proved of considerable value. Among these are the diagnosis of an iron chlorosis in fruit trees at East Malling ; the determination of the cause and cure of a disease of apples in Canada and New Zealand as a result of boron deficiency and of a dieback in apple trees in South Australia due to copper deficiency ; the tracing of the cause of a chlorosis of tea in East Africa to a deficient sulphur reserve in the soil ; the increase in vigour and freedom from attack by insects of injected apple trees and the control of silver leaf disease by the injection of nutrient salts or other substances in England.

In a foreword to the communication, Prof. V. H. Blackman of the Research Institute of Plant Physiology, Imperial College of Science, London, states that as a result of " his seven years most fruitful study of plant injection, Dr. Roach has developed it into a precise technique which can be followed by others and has thus placed in our hands a new instrument of great value in both pure and applied biology". No further commendation is necessary to ensure for the monograph a wide circulation. It is very well documented and illustrated, containing over 175 references to literature and as many as 47 diagrams and two half-tone plates.—A.W.R.J.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED FEBRUARY 28, 1939

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1939	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Foot-and-mouth disease	..	..	..	.	..	..
	Piroplasmosis	..	..	..	..		..
	Blackquarter	1	..	1	..	..	..
	Rabies	1	..	..	..		1
Colombo Municipality	Foot-and-mouth disease	15	15	2	11	1	1
	Anthrax	..	..	..	..	..	..
	Rabies	..	..	..	..	..	
	Piroplasmosis	2	2	..	2	..	
Cattle Quarantine Station	Foot-and-mouth disease	..	.	..	..	..	..
	Anthrax	14	10	14	..		..
Central	Foot-and-mouth disease	40	40	..	.	40	..
	Anthrax	1	1	1	..	..	..
	Rabies	4	2	..	..	..	4
	Contagious mange	6	6	..	1	5	..
	Blackquarter	1	1	1	.	..	..
	Piroplasmosis	5	5	1	4	..	..
Southern	Foot-and-mouth disease	..	..	..	..	..	.
	Rabies	..	..	..	..	..	..
Northern	Foot-and-mouth disease	109	40	5	96	8	..
	Rabies	..	..	..	..	..	..
Eastern	Foot-and-mouth disease	2	2	..	..	2	..
North-Western	Foot-and-mouth disease	10	10	..	..	10	..
	Goat Pox	..	..	.	..	..	..
	Haemorrhagic Septicaemia	..	..	..	..	..	..
	Piroplasmosis	..	..	..	..	..	..
	Contagious mange	..	..	..	..	..	..
	Rabies	1	..	..	..	..	1
North-Central	Foot-and-mouth disease	1,276	238	..	1,058	238	.
	Blackquarter	..	..	..	..	..	..
	Haemorrhagic Septicaemia	.	..	..	..	..	..
Uva	Foot-and-mouth disease	..	..	..	..	..	..
	Rabies	..	..	..	..	..	..
	Blackquarter	..	..	..	..	..	..
Sabaragamuwa	Foot-and-mouth disease	..	..	..	..	.	..
	Haemorrhagic Septicaemia	1	..	1	..	..	..

Department of Agriculture,
Peradeniya, March 16, 1939.

T. M. Z. MAHAMOOTH,
for Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, FEBRUARY, 1939

STATION	Temperature: Mean Maximum	Temperature: Difference from Average	Temperature: Mean Minimum	Temperature: Difference from Average	Humidity: Day	Humidity: Night (from Minimum)	Amount of Cloud	Rainfall: Amount	Rainfall: No. of Rainy Days	Rainfall: Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	87·5	+0·9	69·4	—2·8	64	90	2·6	0·05	2	— 2·15
Puttalam ..	89·4	+1·4	68·2	—2·0	68	92	3·8	0·73	2	— 0·34
Mannar ..	85·5	—1·2	71·9	—1·9	68	90	3·2	1·24	3	— 0·49
Jaffna ..	84·4	—1·3	70·7	—1·7	66	93	3·2	4·20	1	+ 3·04
Trincomalee ..	81·1	—1·7	74·7	—1·1	76	84	3·8	2·42	5	+ 0·38
Batticaloa ..	81·7	—1·3	72·6	—1·2	77	88	4·5	2·36	7	— 0·32
Hambantota ..	86·2	+0·3	71·6	—1·3	67	85	2·8	0·28	3	— 0·76
Galle ..	84·4	—0·9	72·3	—1·3	74	88	3·4	4·51	7	+ 1·52
Ratnapura ..	92·6	+1·0	68·7	—2·7	60	90	4·0	0·71	6	— 3·73
Anuradhapura ..	86·1	—0·7	64·5	—5·3	66	97	3·7	3·32	4	+ 1·83
Kurunegala ..	91·0	+1·4	65·8	—3·9	56	92	3·6	0·01	1	— 1·68
Kandy ..	87·2	+1·2	64·3	—3·0	54	84	1·8	0·01	1	— 1·79
Badulla ..	78·0	—1·1	60·1	—3·2	70	94	3·7	1·73	6	— 0·76
Diyatalawa ..	75·5	+0·7	54·9	—1·7	69	78	3·8	0·66	6	— 1·14
Hakgala ..	70·4	+0·6	48·8	—2·1	66	76	5·0	1·37	7	— 2·05
Nuwara Eliya ..	69·6	—0·3	40·8	—3·8	58	88	4·8	0·73	7	— 0·98

For the fifth consecutive month, the rainfall was below normal over the greater part of the Island, stations reporting excess being mainly confined to the Northern and North-Central Provinces and the northern half of the Eastern Province. February is a month of small rainfall averages in general, and rainfall deficits, therefore, cannot usually attain high values. Deficits were generally less than 2 inches, except in the mid- and low-country to the west and south of the main hill masses, where most stations were between 2 and 5 inches below normal.

The greatest deficits were 4·75 inches at Marambekande and 4·70 inches at Detanagalla. The greatest excess was 3·04 inches, at Jaffna, while excesses over 2 inches were reported from Mankulam, Nanchchaduwa, Jaffna College, Kirimutti, Mihintale, and Kadukkamunai.

The highest monthly total was 9·70 inches, at Hendon, while 5 other stations, St. Martin's Upper and Lower, Pilacholai, Valaichchanai, and Kirimutti, all reported totals of over 5 inches. Labugama, with 2·19 inches for the month, was 2·28 inches below normal. A majority of the rainfall stations in Ceylon reported totals of less than 2 inches for the month, the principal exceptions being in the districts along the east coast, on and near the north-eastern slopes of the hills, at the extreme south-west corner of the Island, and in the Jaffna Peninsula. An appreciable number of places, mainly in the North-Western Province, reported no rain at all for February.

During the first half of the month, dry settled weather prevailed, with moderate north-westerly gradients and very low night temperatures. The minimum temperature at Nuwara Eliya fell below freezing point on 5 consecutive nights, between the 4th and 9th, and also on the night of 12–13th, the lowest temperature reached being 28·2°–4° below freezing point—on the morning of the 7th. The minimum temperature recorded at Colombo for the 4–5th, 62·6°F, was only a degree above the lowest ever recorded at that station.

Between the 15th and the 23rd an appreciable amount of rain was experienced over the Island, chiefly as a result of irregularly distributed afternoon or evening thunderstorms. The last five days of the month were particularly dry.

Temperatures were on the whole about normal by day, but were appreciably below normal by night. Cloud amounts and humidity were generally in deficit. The barometric pressure was above normal, while winds at the coast were above average strength, the general direction being north-easterly.

H. JAMESON,
Superintendent, Observatory.

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EDITORIAL

THE ALL-CEYLON CATTLE SHOW OF 1939

THE Cattle Breeders' Association of Ceylon held its first Cattle Show last month and a note by Mr. St. Elmo Wijeyekoon, the Secretary of the Show Committee, published in this number of *The Tropical Agriculturist* gives an account of some of the exhibits. On all sides the show was pronounced to be a great success from the points of the interest evinced by the owners of cattle, of the quality of the animals shown, and of the efficiency of the organization. But this chorus of praise must not be allowed to drown the voices of criticism and of inquiry.

The exhibits came almost entirely from the neighbourhood of Colombo. It is unlikely that this phenomenon provides a true index of the regional distribution of cattle in the Island; nor was the show inadequately advertised. The true explanation appears to be that the expenses connected with the transport of cattle to Colombo from long distances and with their care and feeding in unfamiliar urban surroundings were greater than the average cattle owner was willing to bear. This was a problem which presented itself in India in connexion with the recent All-India Cattle Show held in New Delhi and was solved by the simple expedient of subsidizing the exhibitor. It is understood that the management of that show undertook the feeding of all the cattle during the week the show lasted and also paid a part of the cost of transport to and from New Delhi, while in many cases part of this cost was met by the provincial governments. Perhaps the Indian example would not fail to impress the Cattle Breeders' Association and the different public authorities in Ceylon. It may perhaps be possible in the future for a few progressive Village Committees to pay the expenses of one or two exhibitors from their districts.

Another marked feature of the show was the comparative unpopularity of the section of indigenous breeds. This confirms the opinion expressed by a special Committee of the Central

Board of Agriculture in 1937 that by inadequate care and feeding and by promiscuous breeding indigenous cattle had reached a very low stage of degeneracy. Nothing but the sustained effort of a number of generations can restore them to their rightful place in the agricultural economy of the country. There is no doubt that the Cattle Breeders' Association will pay its special attention to this problem. Perhaps it has a right to expect the Central Government to give some substantial financial backing to its efforts, and it may be suggested that the best form that this financial assistance can take would be the immediate vote of Rs. 10,000 to be given with the accumulated interest as a reward to the first registered breeder of a herd of pure local cattle which would reach a prescribed standard of milk yield.

While there was evidence that some excellent cattle existed in the country, they did not appear to be the product of planned breeding. They were not representative of a type or a standard which had been deliberately fixed as suitable for perpetuation in the country. On the contrary, most of them were either animals imported from abroad singly—like the champion cow of the show—or the casual crosses between imported animals of different breeds. It is doubtful whether, in the conditions in which they are kept and in which their progeny is disposed of, they will make any lasting contribution to the promotion of the policy of the Cattle Breeders' Association—the building up of a few large milking or beef herds each with a marked individuality of its own. It was indeed not expected that at the very first show held by the Association and within one year of its formation there would be any evidence of the fixation of types. The show was intended to provide only a display of the best original material available in the country for the purpose of regulated experiments in breeding, and it is most necessary that the public, the exhibitors, and the Association should realize that the success of the show did not go beyond the scope of this limited objective. The real test of the earnestness of the members will come when in a few years time they have to show the product of a programme of breeding.

ECONOMIC AND AGRONOMIC CONSIDERATIONS IN THE PROFITABLE LOCAL PRODUCTION OF ONIONS

P. M. GAYWALA, M.Ag. (Bombay),
DEMONSTRATOR IN CULTIVATION, FARM SCHOOL, PERADENIYA

ONION is one of the oldest and the most extensively used vegetables. It is cultivated in almost every country where agriculture has been developed, and constitutes an important article of food. There are reasons for its wide popularity. It not only contains valuable nutrients but is credited with remarkable medicinal properties. Besides, it has the great merit of keeping quality for a fairly long period and power to withstand rough handling during transportation which has secured for it a place in international commerce.

There is an extensive use of onion all over Ceylon. It is popular in rural as well as urban areas and finds a ready market. There are chiefly two kinds of onions available in local markets. The first is known as Bombay onion which derives its name from the port from which it is shipped to Colombo. It is produced chiefly in Nasik and Poona Districts of the Bombay Presidency.

The Bombay onion is fairly large-sized and round-shaped and is mostly of light-red colour, but sometimes bulbs of silvery-white colour are also found in the market. Silvery-white coloured bulbs are of mild flavour and are valued comparatively high. The red-coloured bulbs which are most commonly found in the local market are fairly strong-flavoured. On the whole, Bombay onion fetches a comparatively higher price than shallots in the local market and is more appreciated.

The shallot has a compound bulb splitting into bulblets which cohere at the base. This bulb is small-sized, red in colour, strong in flavour and not so round in shape as the Bombay onion. Shallot is grown to a fair extent locally in the Jaffna and up-country districts. The requirements of shallots in the Island are supplied by such local produce as well as by imports from the port of Tuticorin which is the exporting centre for the produce of South India.

It is rather difficult to find out in exact terms the total amounts of onions annually consumed in this country. Exact figures of local production are not available. The following statement

of the quantity and value of imports of onions during the last two years shows that more than two million rupees worth of onions are imported every year.

Quantity and Value of import of onions in Ceylon during the years 1936 and 1937

Year	1936	1937
Quantity in cwt.	608,831	635,873
Value in rupees	2,012,134	2,049,404

Wherever this crop is cultivated in India, it is regarded as one of the most profitable garden crops in village agriculture. The cost of production is not very high, provided right methods of cultivation are followed. Its cultivation does not demand very specialized skill, and the details of cultural practices are simple enough to be grasped by any intelligent cultivator. Climatically, some of the districts in Ceylon are likely to prove quite suitable for the cultivation of onion, more especially the Up-country districts. The prevailing local wholesale price is about four cents per pound, whereas in the villages of the Bombay Presidency it is less than a cent per pound; yet it is a profitable crop there. These facts clearly indicate that the possibilities of profitable local production of Bombay onions are very great. There is hardly any other crop that can offer so splendid an opportunity for profitable cultivation as this. It is, therefore, proposed to outline in the pages that follow the details of the important cultural practices associated with the cultivation of Bombay onions in the important onion growing districts of the Bombay Presidency.

HABITS OF GROWTH OF THE BOMBAY ONION

Onion is generally regarded as a biennial except in the case of some forms such as shallots which are of perennial character. As a biennial Bombay onion has two distinct stages of growth, the first, the vegetative stage in which bulbs are produced by the planting of seed or by transplanting seedlings raised from seed, and the second, the reproductive stage in which seeds are produced by the planting of the bulbs raised in the preceding season. The life of a complete Bombay onion crop is thus of two years' duration. However, a large part of this crop is raised for its bulbs and therefore it is taken as an annual crop, and a small part of the area is devoted to the production of seed.

VARIETIES

There are two chief varieties found in the local market and grown in the Bombay Presidency. The strong-flavoured, red variety occupies a predominating position because it is of a hardy character, is a high yielder, has a large-sized bulb with a comparatively thick skin which enables it to withstand handling during

transport better, and has better keeping quality. The white is a mild-flavoured variety and although, on that account, it fetches a better price, it is not as hardy and high-yielding as the red variety, and its skin is comparatively thin while it cannot withstand the strain of handling to the same extent as the red variety. Its bulb is also comparatively small-sized. The cultivation of this variety is therefore limited.

CLIMATIC REQUIREMENTS

Onion is essentially a winter crop in India. For best results, onion requires a cool climate with plenty of moisture during the early part of the growing period and a relatively dry atmosphere and moderately high temperature during the latter part which help a great deal in proper ripening. In parts of Bombay Presidency where onion cultivation has become established as a permanent industry, the crop is transplanted from the middle of October to the middle of November and harvested in April when there is a fair amount of heat and absence of rain. If it rains during the harvesting period. it will not be possible to cure the bulbs properly and thus the keeping quality will be seriously affected. It is, therefore, desirable to decide on the planting time after fully considering the local conditions so that there should be no possibility of rain at the time of harvesting. The author has grown this crop on the Agricultural College Farm, Poona, for five years and has obtained yields ranging from 31,000 to 37,000 lb. bulbs per acre under ordinary good conditions in some years. The highest yields were obtained in the years 1931–32 and 1932–33. A study of the climatic conditions during the growing period of these two years on the Agricultural College Farm, Poona, which are presented in a statement below in weekly periods, will give a fair idea of the climatic requirements of this crop.

TABLE 1

Climatic conditions by Weekly Periods, 1931–32

Month and year.	Week of the month.	Rainfall during the week in inches.	Mean of temperature during the week.		Mean of humidity.
			Maximum.	Minimum.	
November, 1931	First	2·80	85·8	66·5	86·7
”	Second	0·05	83·1	63·2	86·7
”	Third	—	84·3	51·5	75·3
”	Fourth	—	84·4	52·8	75·4
December, 1931	First	—	82·5	47·1	75·5
”	Second	0·27	76·7	56·4	85·2
”	Third	—	81·2	56·3	91·1
”	Fourth	—	83·2	46·6	79·8

TABLE 1—*contd.*

Climatic conditions by Weekly Periods, 1931–32

Month and year.	Week of the month.	Rainfall during the week in inches.	Mean of temperature during the week: Maximum.	Mean of temperature during the week: Minimum.	Mean of humidity.
January, 1932	First	—	84·5	46·1	80·4
,,	Second	—	83·2	46·8	74·7
,,	Third	—	86·1	47·8	74·7
,,	Fourth	—	90·5	47·5	71·4
February, 1932	First	—	87·7	48·1	82·2
,,	Second	—	87·7	49·2	78·2
,,	Third	—	86·8	49·7	73·0
,,	Fourth	—	90·4	55·3	82·8
March, 1932	First	—	93·6	58·3	75·7
,,	Second	—	96·8	56·1	78·5
,,	Third	—	99·3	58·8	71·7
,,	Fourth	0·03	99·6	61·7	60·9
April, 1932	First	—	101·8	66·0	63·7
,,	Second	0·54	103·2	70·4	72·6
,,	Third	—	99·0	64·2	71·1
,,	Fourth	0.17	101.0	69·5	76·9

TABLE 2

Climatic conditions by Weekly Periods, 1932–33

Month and year.	Week of the month.	Rainfall during the week in inches.	Mean of temperature during the week: Maximum.	Mean of temperature during the week: Minimum.	Mean of humidity.
November, 1932	First	0·08	86·8	62·0	83·3
,,	Second	—	86·0	49·7	78·0
,,	Third	1·03	86·6	59·6	81·0
,,	Fourth	—	84·2	60·5	81·6
December, 1932	First	0·59	86·3	55·3	88·7
,,	Second	—	84·5	50·7	78·9
,,	Third	—	84·7	44·6	74·4
,,	Fourth	—	84·3	48·1	78·7
January, 1933	First	—	86·1	49·0	84·2
,,	Second	—	85·2	45·7	78·0
,,	Third	—	89·7	51·0	82·6
,,	Fourth	—	85·3	48·1	89·1
February, 1933	First	—	91·2	52·8	83·1
,,	Second	—	92·7	53·1	79·2
,,	Third	—	91·3	50·5	77·2
,,	Fourth	—	90·0	52·6	79·0
March, 1933	First	—	94·8	53·6	72·7
,,	Second	—	97·7	60·0	76·4
,,	Third	—	98·9	61·1	76·2
,,	Fourth	—	97·6	60·0	73·1
April, 1933	First	—	103·6	62·9	67·3
,,	Second	—	97·7	69·9	65·2
,,	Third	—	102·9	71·0	59·3
,,	Fourth	—	100·8	66·7	59·5

From the climatic point of view, therefore, certain up-country districts of Ceylon may prove suitable for the cultivation of this crop. The Jaffna District, although it does not have such low minimum temperatures as Poona, grows with a fair measure of success crops such as cabbage and cauliflower and, therefore, it may be possible to grow this crop, too, there. A few preliminary trials would clearly indicate the extent to which this crop can be successfully introduced in Jaffna District.

SUITABLE SOILS

The best soil for onion is a rich sandy to clay loam which is freely workable, retentive of moisture and yet well-drained, of fair depth and well supplied with organic matter. Heavier loams do yield profitable crops when properly handled, but should receive a sufficient amount of organic manures to prevent baking which damages the growing plants. The main requirements are a high state of fertility, excellent physical condition or tilth, sufficient drainage in places of heavy rainfall and freedom from weeds. Stiff, water-stagnated and low-lying lands are not suitable for this crop. Lighter types of soils produce bulbs with a brighter skin than those produced on heavier soils. Onion is not able to tolerate strongly acidic soils, whereas on slightly alkaline soils, it produces a fairly good growth.

METHODS OF CULTIVATION

This, being a very profitable crop, offers special inducement for the employment of intensive cultural methods. The cultivation of onion is not difficult in itself, but close attention and frequent cultivation for the control of weeds are necessary. If weeds are not effectively controlled from the very start, the cost of subsequent control will be high and the yield will be appreciably reduced. It is, therefore, desirable that onion should follow a crop which has remained free from weeds. Again, this crop should not be planted year after year on the same land, but some system of crop rotation should be adopted because continuous cropping is likely to cause the land to be infested with pests to such an extent as to render it unprofitable for future cultivation. Crops like beans, grams, groundnuts, sweet potatoes or green manure crops can with advantage be included in the rotational cropping scheme.

PREPARATORY CULTIVATION

Land intended for this crop should be thoroughly well prepared. The old saying "as fine as onion bed" has its significance. Operations of preparatory tillage such as ploughing, harrowing and levelling should be properly carried out. As the crop is a surface feeder, ploughing to a depth of 6 to 7 inches is sufficient. Farm-yard manure or compost, at the rate of 10 tons per acre,

is spread over the land and incorporated into the soil during the course of subsequent harrowing operations. The land should be brought to as level a condition as possible so that there may be no difficulty at the time of irrigation.

PLANTING

The most common method of planting this crop in the Bombay Presidency is to sow the seed in specially prepared, raised nursery beds and to transplant the seedlings in the permanent field when they are about six weeks old. The chief advantages gained by the transplanting method are a great economy in the cost of planting material, an opportunity to reject unhealthy and inferior seedlings, a uniform stand and bulbs of regular size.

An area of about 1,600 to 1,800 square feet of nursery beds is required for raising seedlings sufficient to plant an acre. Farmyard manure, at the rate of about 25 tons per acre, is applied to nursery beds which are then prepared in a manner similar to the broad ridges intended for planting ginger or turmeric. These beds are about 3 feet wide at the top surface, and are as long as the level of the land will permit of even distribution of water. The beds should be fairly compact so as to ensure good germination. Seeds are sown evenly on these beds in shallow furrows 3 to 4 inches apart across the bed. Ten pounds of seed will produce seedlings sufficient for transplanting an acre of land. Nursery beds require to be lightly watered and weeded frequently. Seeds complete their germination within a week. By six weeks' time when the seedlings are 5 to 6 inches high, they are ready for transplanting.

The land for transplanting onions can be laid out in two different ways. The flat bed is most commonly followed, and it is particularly suitable on lighter types of soil. The great advantage in its favour is that it permits of the production of medium-sized, round-shaped, uniform bulbs without much splitting and bifurcating. The bulbs obtained from this method have better keeping quality. The other is the ridge and furrow method chiefly adopted on heavier types of soil so as to prevent stagnation of water. Ridges are prepared 18 inches apart and water channels across the ridges and furrows are opened 12 to 16 feet apart for effective and even distribution of water. Seedlings are transplanted on both sides of the ridges. The bulbs obtained by this method are relatively large-sized and much more succulent and watery, but splitting and bifurcation occur to a much greater extent. The quality is therefore inferior.

In order to make the uprooting easy, the nursery beds are irrigated in the evening before the day of transplanting. Seedlings are carefully uprooted just before they are required for

transplanting and carried to the place of transplanting in baskets with mud adhering to the roots. Immediately before transplanting, the beds or furrows are irrigated and, when sufficient soaking has taken place, the seedlings are transplanted in the moist land at the rate of only one seedling in each place. More than one seedling is undesirable as that would retard the healthy growth of bulbs. The spacing between plants on the sides of the ridges is 4 inches. In flat beds the spacing of 9 inches by 4 inches is provided. There is a tendency among some farmers in canal-irrigated areas to transplant seedlings too widely apart. This results in delay in maturity and in unduly large-sized bulbs which have a tendency for splitting and bifurcation. Closer planting is therefore an advantage from the point of view of quality as well as quantity. About 25 to 30 women are required to transplant an acre of land in a day. The crop requires during its early stage ample moisture close to the plants for the development of the root system. Therefore, continuous mild rain or comparatively frequent irrigation is required in the first fortnight. If the planting is done during the dry period, a second irrigation on the third day, a third and a fourth irrigation at an interval of four or five days are necessary. The crop gets established within a week. In the case of seedlings that have failed to establish within 10 days, the gaps are to be promptly filled in.

MANURING

Over and above the organic manure incorporated into the soil during the course of preparatory tillage, it is necessary to supply artificial fertilizers on account of the intensive character of cultivation. Rao Bahadur D. L. Sahasrabuddhe, the former Agricultural Chemist to the Government of Bombay, in Bulletin No. 174 of the Bombay Agricultural Department, states that an average onion crop yielding 14,000 lb. of bulbs, removes from the soil 47·6 lb. nitrogen, 27·8 lb phosphoric acid, 52·4 lb. potash and 38·9 lb. lime. The author carried out intensive field experiments for a period of five years on the Agricultural College Farm, Poona, under the guidance of Mr. V. G. Gokhale, then Professor of Agriculture and Principal, College of Agriculture, Poona, with a variety of fertilizers in order to ascertain the manurial requirements of this crop. The results clearly demonstrated that phosphoric acid and potash did not appear to be important yield-increasing elements and sometimes they even depressed the yield. Nitrogen in the form of sulphate of ammonia or nitrate of soda at 40 lb. nitrogen per acre, that is, 192 lb. sulphate of ammonia or 266 lb. nitrate of soda per acre, improved the yield to a very marked extent resulting in statistically significant increases and high economic returns. These nitrogenous fertilizers are applied as a top-dressing about three weeks after transplanting.

AFTER-CULTIVATION

Onion is a fairly hardy and drought-resistant crop and, therefore, need not be over-irrigated after the first growth has commenced. Excessive irrigation results in unduly high succulence of bulbs which is not a desirable feature from the point of view of keeping quality. However, the plants must be kept growing. Early in the season, the growth is particularly rapid and if it is checked temporarily owing to shortage of water, the outer scales appear as if matured. When irrigation is again given, the inner scales resume growth, thereby splitting the outer ones. This is one of the primary causes of splits and doubles when onion is grown under irregular irrigation. During the dry period, the fifth and subsequent irrigations till the crop attains maturity are given at an interval of 7 days in light loamy soils and 10 days in clay loam soils.

Other chief requirements are frequent stirring of the surface soil and removal of weeds, care being taken to avoid damage to the feeding roots. On account of close planting, bullock intercultivation is not possible. In the case of the ridge and furrow method the ridges and furrows, and in the case of flat beds the surrounding bunds, require to be periodically repaired. If the surface soil is rendered too compact by the beating action of heavy rain, it should be loosened by breaking the crust by means of a rake or weeding hook.

The crop finishes vegetative growth in about 3½ months of transplanting and soon after this the flowering tops known as "poles" begin to appear. For a bulb-crop the growth of poles is not to be encouraged as the nutrition available to bulbs is thereby diverted to the rapidly growing poles. The poles are therefore cut off soon after they appear and, to prevent their growth in the case of other plants, the necks of the plants are pressed down by running a wooden plank over the field. If the area under cultivation is small, the necks of plants can be pressed under human feet. The pressing down of necks also helps in quick ripening of the bulbs. Irrigation is stopped at this stage and the bulbs are allowed to ripen under dry conditions. When the leaves, after turning yellow, begin to droop and when the outer skins of the bulbs appear dry, the crop is considered ready for harvest. It is not desirable to allow the crop to stand on the land for any length of time after the tops have died as the bulbs are then damaged by exposure to sun or they are likely to be ruined by a spell of wet weather. The interval between transplanting and harvesting ranges from 4½ to 5 months.

HARVESTING

The crop is harvested by uprooting by hand the mature plants with the bulbs. As the onion bulbs are very close to the surface

soil and as they are very shallow-rooted, no difficulty is experienced in harvesting by this method. After uprooting the bulbs, the roots and the leaves should be cut off and the adhering earth removed. Loose, thin, outer papery scales should also be removed. Bulbs that have been damaged or are bifurcated should be separated as they cannot keep well during the storage period On an average a woman can harvest and clean 500 to 600 lb. of bulbs in a day. They are then thinly spread under shade and allowed to dry. Care must be taken to guard against bruising while handling the bulbs. They should be kept in as cool and dry a place as possible.

YIELDS

The average fair yield of this crop in Nasik and Poona Districts is 13,000 to 20,000 lb. per acre. When the crop is badly attacked by pests, the yield is much below the average. Under good cultivation and when the crop is free from a severe attack of pests, the yield easily ranges from 25,000 to 40,000 lb. per acre.

STORAGE

As the onion is in demand throughout the year and as it is capable of successful storage with proper care and precaution, it offers an opportunity for the producer to realize his best price after the glut of the harvesting season is over. The Indian farmer, however, does not himself undertake the storage of onion as a local dealer is almost always available to purchase his crop immediately after harvest. It is the dealer who takes up the business of storage.

Onions can be stored with minimum loss in large quantity if they are kept in a dry, cool and well-ventilated place. Special storage houses prepared from grass thatchings are constructed by wholesale onion dealers. The walls of these storage houses are made of split bamboos with vacant spaces between them so as to admit ample circulation of air.

Thick necks or those that are not fully matured and are soft should not be brought for storage along with other good bulbs. Satisfactory drying to drive off unduly high moisture content is quite essential before successful storage. Drying of the outer skin to a fine papery texture and the feeling of brittle touch are indications of satisfactory drying. A serious trouble of wet rot will spread if insufficiently dried onions are taken to the storage house. There is considerable loss in storage due to drying of bulbs as well as to damage caused by rotting. In Bombay, this loss sometimes amounts to from 25 to 40 per cent. during a storage period of six months, but it is amply compensated by high prices obtainable off season. On account of the relatively low maximum temperature prevailing in most parts of Ceylon, the storage losses are likely to be comparatively low in Ceylon.

Onions should not be heaped too high in stores but should be thinly and evenly spread allowing free circulation of air. Bulbs when kept on racks made close together will economize storage space and will be stored better. For short periods bulbs are sometimes stored in gunny bags in well ventilated places. The storage houses require to be periodically examined to sort out and remove the rotten bulbs.

PESTS

The crop is chiefly liable to an attack of thrips which crowd on the surface of the leaf and suck the sap. This results in appreciable loss in the vitality of the plant, and leaves become white-spotted, curl and die. This trouble appears to be responsible for interfering with the physiological processes concerned with the development of the bulb and hence the yield is directly affected. The attack which largely depends on the climatic conditions is not of an equal magnitude in all the years. In mild form it does not cause serious reduction in yield. A severe attack, however, reduces almost by half the yield of an apparently promising crop. The attack of thrips can be controlled to some extent by the timely spraying with nicotine sulphate solution. A heavy shower of rain washes away a large number of thrips and the crop then improves.

METHOD OF SEED PRODUCTION

In the case of a crop like onion where the viability of the seeds is limited to one season only, it is not a good policy to rely on outside sources for the supply of seed. The seed so purchased, besides being costly, is likely to be of doubtful germinating power. Whenever possible, the farmer should make provision for growing his own requirements of seed on a small area in the corner of his main bulb-crop. Most of the onion growers in India raise their own seed, and by so doing they produce seed that is better adapted to their specific local requirements than the supplies generally procured from markets.

Though the plants raised from seed send out flowering shoots in a single season, the seed obtained is not of good quality and cannot be relied upon to produce a crop of bulbs. In order to obtain seed capable of developing into a desirable type of bulbs, a limited number of well-developed, medium-sized bulbs of the best appearance are selected from a bulb-crop and they are given 4 to 5 months' rest by providing careful storage and are then utilized for planting.

For the production of seed, the climate should be cool and moist till the commencement of flowering, and then fairly warm and dry without rain. The period of harvesting and curing of seed should be necessarily dry.

The land intended for seed production receives the same thorough preparatory cultivation and liberal manuring as that for raising a bulb-crop. Ridges and furrows, 2 or 2½ feet apart, should be opened by a small ridger or Victory plough. Sets for planting are prepared by rejecting a portion of about one-third of the top of the bulb; only the rest of the bulb is utilized for planting. If the upper one-third part is not removed at the time of planting, all the poles will have to force their way out through one mouth only. The cutting away of the top part permits of easy passage for the emerging poles and stimulates vigorous leafy growth. About 1,000 to 1,200 lb. of bulbs are required to plant an acre. The sets are planted in furrows at a spacing of 1½ feet and covered over with a layer of soil about 2 inches thick.

Planting season, frequency of irrigation, requirements in weeding and soil-stirring are practically the same as with the bulb-crop. When the plants are about a foot high, that is, after about six weeks' growth, the crop is earthed up and made to stand on ridges. Within a fortnight of earthing up, on an average 5 to 8 shoots with flowering heads come out from each bulb. The crop is ready for harvesting in 4½ to 5 months.

The crop is not harvested in one operation. The heads are to be collected as they are ready at an interval of 4 or 5 days by cutting them one by one, with a short piece of stalk attached, by hand. The proper time to harvest is when the seed after passing the dough stage has begun hardening and has assumed a deep black colour. Black colour alone is not dependable as an indication of ripening as the seed assumes a black colour at a much earlier stage before maturity. Seed stalks, when mature, must be promptly collected and, if delayed, a great portion of seed is lost by scattering. The heads are then spread over a mat in a drying place in a thin layer and allowed to dry in the sun. They are turned over daily until they are dry enough to be threshed. Threshing is usually done by beating with wooden flails and seeds are finally cleaned by careful winnowing.

In some places there is a pratice of separating the good heavy seeds from the inferior light ones by putting them in a shallow vessel containing water. Those that float are light and are discarded. The heavy seeds which sink should be taken out at once and allowed to dry fully. However in places where the weather is uncertain and the seeds cannot be quickly dried owing to unexpected rain, this method of separating out light seeds is not safe and should not be practised.

A good average crop yields about 300 to 450 lb. seed per acre.

SOME SOIL AND MANURIAL PROBLEMS OF CITRUS CULTURE IN CEYLON

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THE area under systematically-cultivated citrus in Ceylon has been slowly but steadily extending during the past few years and is likely to be further extended in the future. It is, therefore, essential that those who grow or contemplate growing the crop should be acquainted with some of the important soil and manurial problems affecting successful citrus culture in the Island.

Citrus trees do best on deep, well-drained, medium loams with no physical obstruction to root development and water movement within a soil depth of about 4 feet. Thus low-lying, clay soils in which water drainage is impeded, very hard laterite (cabook) soils such as not infrequently occur in the humid low-country, soils in which the permanent water table is too near the surface, and those with an impervious heavy clay or hardpan sub-soil are unsuitable, or, at any rate, unfavourable for the crop unless ameliorative measures, *e.g.*, surface and sub-soil drainage, are adopted. Even so, it is doubtful whether the returns would, in many cases, be sufficiently remunerative to justify the expenditure involved. Soils with a gravel sub-soil, especially in dry and semi-dry areas where irrigation is not feasible, and those which are too rocky are also not generally to be recommended.

From the chemical standpoint citrus soils should be well supplied with organic matter and nitrogen, available lime, potash and phosphoric acid, and should contain a sufficiency of the minor elements, *e.g.*, boron, necessary for the health of the trees. Soils containing an excess of organic matter or lime are, however, to be avoided as, on such soils, the trees develop certain physiological disorders and become unhealthy. Fortunately these soils are extremely rare in Ceylon. On the other hand, strongly acid soils such as the wet patana or the laterite soils, are disadvantageous for more than one reason, the chief being their lack of lime. Soils which are strongly alkaline and contain excessive quantities of soluble sodium and magnesium salts are also unsuited to the crop. These, again, occur but seldom in Ceylon.

Citrus is a crop which absorbs large amounts of plant food from the soil. It has been reckoned that an acre of citrus giving average yields removes from the soil about 55 lb. nitrogen, 12 lb. phosphoric acid, 45 lb. potash and 85 lb. lime. It is obvious, therefore, that if citrus is to be grown as a commercial proposition it has to be fairly heavily manured and limed.

An essential requirement for successful citrus cultivation is an adequate amount of soil organic matter. Ceylon soils are generally deficient in this respect. The deficiency should be made good by the application of farmyard manure, compost and green manure. A fully-bearing citrus tree could receive with advantage up to about 200 lb. of farmyard or other bulky organic manure per annum. A suitable time of application is soon after the crop has been picked. Younger trees should receive proportionately smaller amounts. Green manure could replace farmyard manure in part, but, where cover crops are grown, it is essential that they be turned into the soil or cut and left as a mulch on the surface before the drought sets in. It is the experience of growers in certain citrus-growing countries that a permanent cover in the grove affects both the growth and yield of the trees adversely. This is due to the competition between the roots of the main and the cover crop for the moisture and nutrients of the soil. Recent work at the Experiment Station, Peradeniya, by the Demonstrator in Plant Propagation has confirmed this observation.

For the healthy growth of citrus an adequate supply of lime in the soil is necessary. Citrus trees absorb large quantities of calcium, their demands for this element becoming greater with advancing age. It has been found that calcium constitutes about a third of the ash content of healthy citrus leaves, while mottled or chlorotic leaves, *i.e.*, those which have developed a characteristic yellowing, in part or whole, have much lower proportions of this element. An acute and prolonged deficiency of calcium results in the mottling and chlorosis of the leaves, the die-back of the branches, poor crop yields and ultimately even the death of the trees. The periodical liming of citrus trees is therefore of fundamental importance in all but a few areas where the crop is grown. The main exceptions are those where the soils are derived from Miocene limestone, *e.g.*, parts of the Jaffna Peninsula, or associated with crystalline limestone as in the Matale–Dambulla district. Even in these areas, on certain soil types citrus will benefit by liming. It is tentatively suggested that where lime is applied the annual application be varied from 4 to 15 lb. per tree, depending on its age. Experiment might indicate that larger doses are necessary.

A deficiency of lime in the soil is only one of several causes of chlorosis in citrus. Others are unsuitable physical soil conditions such as those already enumerated, unfavourable chemical conditions, *e.g.*, excess of lime, low iron availability, deficiency in the minor elements, zinc, boron, manganese, magnesium, copper, incompatibility of stock and scion, eelworm, &c. But evidence is forthcoming that trees grown on naturally calcium-deficient soils and which have not received adequate applications of lime are most liable to chlorosis. Certain species of citrus, *e.g.*, mandarins, are more susceptible than others, but none is immune. Owing to its fairly wide prevalence in Ceylon, citrus chlorosis is at present engaging the attention of the Departmental officers concerned with the subject.

In regard to artificial fertilizers for citrus, numerous experiments in other countries have shown that the best response is obtained with nitrogenous fertilizers. Local experience confirms this finding. Potassic and phosphatic fertilizers are also beneficial on many local soils and essential on the sandy soils which are deficient in these elements. Especially when bulky organic manures are used in insufficient quantity, part of the nitrogen applied to the crop might be given in organic form, *e.g.*, as blood meal. Any of the ordinary nitrogenous or compound nitrogen and phosphoric acid fertilizers may be applied, but information in regard to the use of cyanamide for young citrus locally is scanty. Superphosphate and basic slag are suitable phosphatic fertilizers to apply. The latter is particularly advantageous on acid soils. Potassium is best given as sulphate of potash, but kainit has advantages on certain types of soils.

Only brief reference will be made to the questions of fertilizer mixtures suited to different soil and climatic conditions, and the best times and methods of application. Definite data on these points have yet to be obtained from carefully planned field trials. With the establishment of a Government citrus plantation at Minneriya, the investigation of some of these problems will be taken in hand. In the meantime the following mixtures, based on the experience of other citrus growing countries and a consideration of local soil conditions, are suggested for trial on soils of average fertility, as they have been found to give beneficial results where tried :—

3 parts sulphate of ammonia or nitrate of soda
2 to 3 parts superphosphate or basic slag
1 part sulphate of potash

at the rate of 4 to 10 lb. per *bearing* tree, annually, depending on the age. The suitable combination of nitrogenous and phosphatic fertilizers should be used. The mixture is advantageously applied about a month before flowering. A month

or so after the setting of fruit 1 or 2 lb. of sulphate of ammonia or nitrate of soda per tree may be given, the quantity varying with the age. Manuring should not be done in very wet weather nor in times of drought. A period of light rains is the most favourable.

In regard to methods of application, experiments abroad have indicated that soluble fertilizers are best applied dissolved in the irrigation water. Where this is not practicable it is suggested that fertilizers and manures for citrus be broadcast and fairly deeply forked into the soil within a circular area extending from a distance of about 2 ft. from the trunk to about 1 ft. beyond the circumference or drip of the tree. Care should be taken that no thick roots are damaged in the process.

It may be useful to refer briefly to the question of irrigation for citrus. It would be futile to attempt to grow citrus as a commercial proposition in the dry zone without some form of irrigation. Generally speaking an irrigation about once a fortnight should suffice during the period of drought. The quality of the irrigation water is important. It has been found in Palestine that irrigation water containing more than 350 parts per million of chlorine is generally unsuitable for the crop. Very brackish water should, therefore, be avoided for the purpose.

If citrus cultivation on a large scale is to be profitable, it is essential that the land be carefully selected, irrigation facilities provided if the area is in the dry zone, and due attention be given to the cultivation, liming and manuring of the trees.

CHEMICAL AND AGRICULTURAL NOTES FROM THE COCONUT RESEARCH SCHEME, CEYLON

III. LOSS OF AMMONIA FROM FERTILIZER MIXTURES CONTAINING SULPHATE OF AMMONIA AND MINERAL PHOSPHATES

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THE question of possible losses of nitrogen (as ammonia) when sulphate of ammonia and ground mineral phosphates (such as Saphos, Ephos and Safaga phosphates) are mixed is one of considerable practical importance. It is usually recommended that these constituents may be safely used in manure mixtures, but the possibility of the presence in mineral phosphates of 10 to 15 per cent. of lime as calcium carbonate which will react with sulphate of ammonia under damp tropical conditions should not be ignored.

Akhurst (1), working at the Rubber Research Institute, Malaya, in 1936, using mixtures of sulphate of ammonia with three different types of rock phosphates (Christmas Island, Gafsa and Cheribon), showed that appreciable losses of nitrogen can occur from the mixtures on storage. Losses of nitrogen amounting from 7 to 13 per cent. were observed after six days, and from 16 to 17 per cent. after 13 days.

Very similar results were obtained by Beeson and Jacob (2) working at the U. S. A. Bureau of Chemistry and Soils. Using calcined rock phosphate it was shown that the losses which occur are small when all materials are kept dry, but considerable when the humidity is high, particularly when potash salts are present.

Some results obtained in the Coconut Research Scheme laboratory are worth recording.

Two parts sulphate of ammonia, four parts Saphos phosphate, and two parts muriate of potash, in the proportions generally used in manure mixtures for coconuts were thoroughly

mixed and aliquot portions were stored in small miniature manure bags. Determinations of ammonia were made periodically.

Even at the time of mixing a distinct smell of ammonia was observed. That appreciable losses of ammonia occur is shown by the following data :—

	Nitrogen Per cent.		Loss of Nitrogen Per cent.	
At Mixing.	After 9 days.	After 1 month.	After 9 days.	After 1 month.
5·69	5·40	4·65	5·2	18·3

Beeson and Jacob (*loc. cit.*) report that the loss of nitrogen increases with the relative humidity of the air ; and that the rate of loss depends on the initial moisture content and the relative proportion of the mixture exposed to the atmosphere. Mixtures containing below one per cent. of moisture do not lose ammonia when stored in closed containers.

It is not necessary here to discuss the chemical reactions occurring in the mixture, beyond pointing out that the presence of " free lime " in the original phosphate is not essential for the liberation of ammonia. Beeson and Jacob (*loc. cit.*) indeed point out that in the presence of water α tricalcium phosphate can decompose sulphate of ammonia.

Whatever the chemical reactions may be, losses of nitrogen as ammonia are found to occur from fertilizer mixtures containing sulphate of ammonia and mineral phosphates when these are stored for any length of time under the hot and humid conditions of most Ceylon coconut districts. The effect is enhanced by the presence, in the mixture, of potash salts which rapidly absorb moisture. In the trial reported here, the mixture after two months had become a damp, sticky mass resembling puddled clay.

Separate application of the constituents of such a mixture would probably be unobjectionable, but a large proportion of coconut estates use ready-mixed fertilizer mixtures, and since the time of application of manures depends upon the vagaries of weather, long storage is often inevitable. Accordingly, the use of sulphate of ammonia with mineral phosphates in mixed fertilizers is not recommended.

It is possible that different degrees of loss will be found with different grades of phosphate and it is proposed to carry out further investigations in co-operation with the Tea Research Institute.

REFERENCES

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THE CONTROL OF THE GIANT SNAIL (ACHATINA FULICA FER.) AT THE TABBOWA VEGETABLE SEED STATION BY THE USE OF "META-BRAN" BAIT TRAPS

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THE prevalence of snails at the Tabbowa colony during 1937 and 1938, and the vast amount of damage to agricultural crops resulting from their attack in the area led to a trial of the new "Meta-Bran" bait which has been suggested as a measure of control. The trial, which was conducted at the Tabbowa Vegetable Seed Station, was commenced in November, 1938, and forms the subject of these notes.

PREPARATION OF THE "META-BRAN" BAIT

In preparing the bait, half an ounce of "Meta," thoroughly powdered, was mixed with 1 lb. of rice-bran in a bucket. The mixture was then gradually wetted with warm water and well stirred to a consistency of a mash which could be easily moulded into balls, each the size of a small lime fruit. About 26 oz. of water were required to make 1 lb. of bait from which 60 bait-balls were prepared.

SETTING OF "META-BRAN" BAIT TRAPS IN THE FIELD

The prepared "Meta-Bran" bait-balls were placed in the field at intervals of 15 feet throughout the infested area. As the baits are easily washed away by rain and adversely affected by hardening if exposed to the intense heat of the sun, they were covered over with lengths of corrugated iron sheetings 9″ × 8″ shaped to form a protecting hood over each bait. These hoods proved to be exceedingly useful in the field.

During rainy weather, when snails are usually most prevalent, it was found necessary to increase the number of baits placed in the field by reducing the interval between the traps to 10 feet.

Whenever the baits showed signs of hardening and drying, they were collected into a bucket, broken up, wetted with warm water and re-moulded into baits. In this manner the bait-balls can be used over and over again until they have been consumed by the snails :—

COLLECTION AND DISPOSAL OF SNAILS

The snails were usually attracted to the baits at night and were found dead the following morning. The dead snails were collected daily and buried, leaving the baits exposed for a further catch.

The following table shows the results of the trial conducted at the Tabbowa Vegetable Seed Station from November 3, 1938, to February 28, 1939 :—

Period.	No. of Traps.	No. of Dead Snails collected from Traps.	Rainfall. Inches.
November 3–30, 1938	88	4,462	5·63
December 1–31, 1938	432	8,682	3·98
January 1–31, 1939	500	71,814	4·9
February 1–28, 1939	550	22,080	0·23

The results so far obtained of snail control by the use of "Meta-Bran" bait traps have been most encouraging, and the trials will be continued during the rainy season.

COST OF "META-BRAN" BAITS

The cost per acre of "Meta-Bran" bait, worked out on the assumption that the baits are placed in the field at 15-foot intervals, and using the concentration of half an ounce of "Meta" to one pound of rice-bran, is :—

	Rs	c.
1 oz. "Meta" at 17 cents	0	17
2 lb. rice bran at 2 cents per lb.	0	4
120 "Meta" balls cost	0	21

193 balls (required for an acre) cost 34 cents.

"Meta" packets, each containing 50 briquettes (weighing $7\frac{1}{2}$ oz.) can be purchased from most fertilizer firms at a cost of Re. 1·25 per packet.

ACKNOWLEDGMENT

The preparation of "Meta-Bran" baits described in the above notes was done in accordance with the suggestions of F. Beeley published in *The Journal of the Rubber Research Institute of Malaya*, 1938, Vol. 8, pp. 131–139.

SUMMARY OF LEGISLATION OR OTHER GOVERNMENTAL ACTION ON SOIL CONSERVATION IN VARIOUS COUNTRIES

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THIS summary of the legislation in force or other governmental action taken in various countries on the question of soil conservation was prepared at the express desire of the authorities, as it is considered that all agriculturists and those responsible for land policy in Ceylon should be acquainted with what is being done elsewhere on this problem of important national concern. A briefer summary was previously submitted to the Board of Agriculture by the Soil Conservation Officer. The material for this survey was obtained from various sources. In the case of the United States of America, Union of S. Africa, Malta, Straits Settlements, the Dutch East Indies and New South Wales, copies of legislation and other useful information were received by this Department direct from the countries concerned. Most of the other information was either furnished by the Imperial Bureau of Soil Science or extracted from the valuable publication of the Imperial Bureaux of Soil Science and Pastures and Forage Crops entitled *Erosion and Soil Conservation* by G. V. Jacks and R. O. Whyte. The Imperial Forestry Report Paper No. 14, *A Report on a World Tour for the Study of Soil Erosion Control Methods* by A. Grasovsky was also helpful. Occasional reference was also made to Government publications and other works bearing on the subject, *e. g.*, Memoranda of the Governments of Uganda, Kenya and Tanganyika on Soil Erosion; C. Longabardi's *Land Reclamation in Italy; Soils and Men, the U. S. A. Department of Agriculture Yearbook, 1939.*

While it would have been convenient for the purpose of this summary to have taken the countries in strict alphabetical order, it is considered preferable to make an exception with the United States of America where legislation and governmental activity on soil erosion have perhaps made the greatest advance and to deal with that country first.

UNITED STATES OF AMERICA

In April, 1935, the Congress of the U. S. A. passed an Act "To provide for the protection of land resources against soil erosion, and for other purposes." Under this Act a soil conservation service was created in the Department of Agriculture to conduct a comprehensive national programme for the control and prevention of soil erosion. This service was the outgrowth of the soil erosion service established in October, 1933, under the Department of the Interior. The Act, among other provisions, authorizes the Secretary of Agriculture :—

"(1) to conduct surveys, investigations and research relating to the character of soil erosion and the preventive measures needed, to publish the results of such surveys, investigations, &c., to disseminate information concerning such methods, and to conduct demonstrational projects in areas subject to erosion by wind and water ; and

(2) to co-operate or enter into agreements with, or to furnish financial or other aid to any agency, governmental or otherwise, or any person, subject to such conditions as he may deem necessary, for the purposes of this act."

The Soil Conservation Service exercises the powers conferred on the Secretary of Agriculture by the Act.

An amendment to this Act was passed in February, 1936, "to promote the conservation and profitable use of agricultural land resources by temporary Federal aid to farmers and by providing for a permanent policy of Federal aid to states for such purposes." By this amending Act, the purposes of the previous act were extended to include among others : (1) the preservation and improvement of soil fertility, (2) the promotion of the economic use and conservation of land, (3) the diminution of exploitation and wasteful and unscientific use of national soil resources, (4) the protection of rivers and harbours against the results of soil erosion.

Because of the great need for state legislation to carry out effectively the Federal programme, Congress, by this amending Act, authorized the Secretary of Agriculture to require the adoption of suitable state legislation as a condition of Federal money being spent in any state for erosion-control work. Accordingly, a Standard State Soil Conservation Districts Law was framed by the Department of Agriculture and representatives of a number of the states. In February, 1937, the U. S. President recommended to the 48 State Governors the submission of this standard law to their legislatures. Of these, 25 states adopted legislation on the lines of the standard Act and a number of others adopted modified statutes.

The standard Act provides a procedure by which " Soil Conservation Districts " may be organized and defines their powers. A State Soil Conservation Committee, composed of heads of the Departments of State concerned, is established, which has the power to define the boundaries of each district, to encourage the organization of districts, to co-ordinate the several district programmes, &c.

The procedure for organizing a district is as follows :— Twenty-five landowners may petition the state committee to establish a district. The committee is required to hold a public hearing on the petition and, if satisfied, to define the boundaries of the proposed district, and then to conduct a referendum on the petition. A district is established only if a majority of the votes is cast in favour of it.

Each district is an independent unit and is not subject to the control of the state committee. It is to be governed by a board of five supervisors two of whom are to be appointed by the committee and three to be elected by the land occupiers of the district. Each district has the power (1) to establish and administer erosion-control projects and preventive measures, including financial and other assistance to farmers, (2) to prescribe land-use regulations in the interest of the prevention and control of erosion, such regulations to be first submitted to local referendum and, if approved in the referendum, to have the force of law within the district. A Board of Adjustment is to be established in any district that adopts land-use regulations to which appeals can be made against the observance of these regulations by any land occupier. Decisions of the Board of Adjustment are subjected to review in the local courts.

Funds to finance the operations of the districts come from two sources : (1) direct appropriations out of the State Treasury, (2) grants-in-aid made to the Soil Conservation Service either through the state committee or direct. By June, 1938, 59 soil conservation districts were organized in 16 states. As the Editorial in *The Tropical Agriculturist* of July, 1938, states, this Standard Soil Conservation Act offers the fullest scope possible for " democracy in land use " and is well worth a trial locally.

AUSTRALIA

In *S. Australia* and *Western Australia* where sand drift is an acute problem, Sand Drift Acts have been in operation for a number of years, in order to protect roads, railways and private property.

In *New South Wales*, as recently as October, 1938, a Soil Conservation Act was passed to make provision for the conservation of soil resources and for the mitigation of erosion. A

Soil Conservation Service was created by this act to carry out investigational, propaganda, and "project" work on soil conservation. Provision is made for funds to be advanced to owners or occupiers of land for adopting measures against soil erosion. In areas of "erosion hazard," as defined by the act, action has to be taken against erosion within the area either by the private party concerned or by Government, if the former neglects to do so, in which case costs are recovered from the owner. Appeal against the orders of Government may be made to the Land and Valuation Court.

Catchment areas may be declared "proclaimed works" and as such are protected against damage or interference by private parties. Petitions of inquiry from owners of such lands will be inquired into by the Catchment Areas Protection Board. The Minister is empowered to utilize Government funds to carry out necessary works in such area, or, in certain circumstances, to request the owner to pay or contribute towards their cost. The owner may appeal to the Land and Valuation Court against payment.

The Act provides for the establishment of one or more advisory committees to consider matters relating to soil conservation or erosion-mitigation or any other purpose contemplated by the act. Provision is also made for the alteration of the clauses of certain land leases when the compliance of these would tend to cause erosion on any land.

The Governor is empowered under the Act to prohibit or regulate the destruction of, or interference with, timber or scrub on any lands held under any form of lease or licence from the Crown, or the lighting of fires in any catchment or erosion-hazard area.

BRITISH SOMALILAND

An ordinance entitled "The Preservation of Grazing Areas and Water Ordinance" was enacted in 1936. The District or Assistant District Officer of any district may, in consultation with the Agricultural and Veterinary Officer, and with the approval of the Governor, prohibit grazing, temporarily, in any area where it is deemed desirable. Any stock found in any of the prescribed areas will be impounded till a fine is paid for it by the owner, and, if the fine is not paid, confiscated.

CANADA

The Prairie Farm Rehabilitation Act was passed in 1935 to provide for the rehabilitation of drought and soil-drifting areas in certain provinces. Amendments to the Act passed in 1937 included provision for the establishment of one or more advisory committees. The following were established in 1937: (1) The Prairie Farm Rehabilitation Committee, (2) The

Water Development Committee, (3) The Land Utilization Committee. The functions of the committees are to consider and advise the Minister of Agriculture " as to the best methods to secure the rehabilitation of drought and soil-drifting areas, and to develop and promote within these areas systems of farm practice, tree culture, water supply, land utilization and land settlement that will afford greater economic security."

Expenditure is provided for by Government for the purposes of the act. In 1937-1938, this amounted to two million dollars.

THE DUTCH EAST INDIES

Laws pertaining to the general protection of the soil concern such lands that are alienated to peasants for agricultural purposes. Regulations to suit local circumstances are in force to ensure that such lands are cleared and opened up judiciously. The section relating to the protection of the soil is as follows :— " On sloping land, if there be danger of the cultivated areas being washed away, cultivation should be carried out in terraces and under such conditions as local circumstances require." In the case of lands which are transferred on a specific title (tenancy, building right, leases, &c.), tenants are required to preserve a vegetal covering with a view to protecting, if need be, wells or river banks against erosion. In certain cases, a general protection clause is added.

An ordinance was passed in 1925 for the protection of forest growth around wells and along rivers and rivulets. Where such forest growth does not exist, the tenants cannot oppose the planting up of forest by the authorities.

The general protection of the soil against erosion has not as yet been provided for in the ordinance. In the meanwhile, in the tenancy acts and in all other cases when local circumstances appear to require it, clauses are inserted whereby the tenant has to protect against erosion such areas as are indicated by the forest officers, according to the latter's instructions. Failing compliance, the whole or part of the land may be forfeited without any compensation.

FRANCE

Between 1861 and 1935 the French Administration of Waters and Forests has re-forested approximately 1,200,000 acres at a cost of over 300 million francs of which nearly a fifth has been spent in corrective works. A number of laws permit the forestry administration to ensure that private interests do not obstruct such work. The problem of stabilizing sand dunes along 720 miles of French coast is also undertaken by the forestry service.

ITALY

Technical and legislative measures adopted against soil erosion form part of the Mussolini Integral Land Reclamation Act which came into operation in Italy in 1929. Land reclamation is in the immediate charge of a special Under Secretary of State for Reclamation under the Ministry of Agriculture and Forests. A distinction is made between land reclamation and land improvement works. The latter are carried out on behalf of one or more farms and independently of a general land reclamation plan. Land improvement "Consortia" or associations of landowners are formed for the execution, upkeep and management of land improvements. The cost of such work is met by the State and by the landowners under specified terms. The reconditioning of mountain land is carried out exclusively by the forest service.

JAPAN

In 1897 a Forestry Act was passed which made torrent regulations compulsory throughout the Japanese Empire. This act was apparently amended in 1926. Article 14 of the Act provides for the protection of forests for the following purposes among others: to prevent denudation of the soil; to prevent sand-shifting; to provide protection against the devastation of floods, winds and tides; to ensure a constant source of water supply, &c.

Article 26 provides that without the permission of a local Governor no person may in a protected area cut or damage trees, or bamboos, reclaim land, collect or dig out soil, turf, bogwood, roots of trees or of grasses, or graze livestock. Control measures are, if necessary, enforced on private land, the State or local authorities undertaking five-sixths of the cost.

River training operations are carried out by the Public Works Department and the reafforestation of denuded hillsides by the Forest Department.

KENYA

In Kenya the Fire Prevention Ordinance which applies to all parts of the country and all sections of the community, prohibits the unauthorized burning of grass and trees. In native areas, provision is made for the prevention of soil erosion by a recent amendment of the Native Authorities Ordinance. Control of grazing in these areas has been effected by certain rules under the Crop Production and Livestock Ordinance, 1926. A soil conservation service under the Department of Agriculture has been formed. A draft Land and Water Preservation Bill is at present under consideration. All forest reserves are protected by rules under the Forests Ordinance.

MALTA

In Malta, soil is so valuable that its artificial removal from building sites to areas suitable for agriculture is made compulsory by law.

An ordinance cited as the " Fertile Soil Preservation Ordinance " was passed in 1935 to provide for the preservation of fertile soil. " Fertile soil " means soil which is, in the opinion of the Superintendent of Agriculture, necessary or adaptable for agricultural purposes. Under the ordinance no owner could erect any building on any site without first removing the fertile soil or a part thereof as directed by the Superintendent for utilization in connexion with agriculture. Penalties are imposed for the non-compliance of the provisions of the ordinance. Amendments to it were passed in 1936, one of which permits an appeal to the Governor from the decision of the Director of Agriculture in regard to certain clauses of the act.

NIGERIA

No legislation is in force except the prohibition of grazing in certain areas in which reafforestation and soil conservation measures are being carried out by the Forest Department.

NYASALAND

The legislation in force is embodied in the Forest Laws and Rules. There is usually a clause in the lease, when land is taken up by European farmers, for the replanting of a certain proportion with trees. The prohibition of the destruction of natural vegetation and cultivation of steep slopes was recommended by a committee of the Board of Agriculture as coming within the sphere of rule 5 which reads : " Any Forest Officer or Administrative Officer may at his discretion forbid the felling, cutting and removal of forest produce on the tops and slopes of hills and mountains." A Government Circular, No. 3 of 1936, recommends the following among other measures for the improvement of agriculture and control in the use of the land :—

(1) Soil conservation : by terracing, draining, contour planting and bunding.
(2) Protection of major catchment areas and watersheds by means of forest reserves.
(3) Preservation of natural vegetation on the poorer soils of the country.
(4) Protection of stream-banks and steep hill-slopes under powers of the Forest Laws.
(5) Preservation of belts of forest and natural vegetation on the better lands, to form windbreaks.
(6) The control of bush fires.

RHODESIA

In 1932, a soil erosion committee stressed the need for national action on soil erosion and recommended the establishment of district soil conservation boards under a Central Soil Conservation Advisory Council. Such councils and boards have accordingly been formed in North and South Rhodesia, and on these the farming community is represented. A Soil Conservation Act is under consideration. Financial advances are given on easy terms to farmers to enable them to adopt soil conservation measures, and technical assistance and planting material for use against erosion have been supplied free of cost by the Department of Agriculture. A Soil Conservation Officer is employed by the Native Department to carry out anti-erosion measures in the native areas.

UNION OF SOUTH AFRICA

While legislation exists in the different provinces of the Union in regard to veld burning, afforestation, &c., no legislation has as yet been introduced for combating soil erosion. The Government, however, encourages landowners to prevent erosion by subsidizing the construction of dams, contour banks, weirs and other anti-soil erosion works. Local soil erosion committees consisting of the Magistrate and two farmers appointed by the Agricultural Department have been formed to deal with all applications for assistance, to inspect land and to arrange for technical advice where necessary. Five Government schemes of assistance are available to farmers. Prior approval of the Department of Agriculture to the proposed scheme is required in every case before any subsidy could be granted. The schemes are as follows :—

Scheme A.—A bonus of 33⅓ per cent. is paid on the final evaluation of works completed by the applicant, at his own expense, to the satisfaction of the Department. The maximum amount payable on one farm is £166.

Scheme B.—A loan of not more than £350 is granted to a registered landowner. A subsidy of 25 per cent. on the final evaluation is also paid.

Scheme C.—The State meets seven-eighths of the wages of unemployed European labourers engaged in soil conservation work approved by the Department.

Scheme D.—A loan without interest up to £50 is granted for the purchase of materials, implements, &c.

Scheme E.—A bonus of 25 per cent. may be paid on the cost of fencing material used for fencing-in trees or shrubs planted for controlling soil erosion. The maximum bonus is £62.

STRAITS SETTLEMENTS

An ordinance was passed in December, 1937, entitled "The Hill Lands Ordinance," the object of which is "to restrain and prevent the use and cultivation of hilly land in a manner likely to endanger health or property." Under the ordinance, no person can cultivate any hill-land with "short-term crops" such as annual crops, pineapples, bananas, derris, except under permit, and then only within the garden of a house. No hill-land can be cleared or trees, plants, undergrowth, weeds, grass or vegetation removed or destroyed on such land except by permit for cultivation with crops other than short-term crops. A person who has been refused a permit has the right of appeal to the Governor in Council. The Governor has the power to direct that any hill-land shall be acquired for the purpose of preventing soil erosion whenever it is deemed desirable to do so. Contravention of the clauses of the ordinance renders the party liable to a fine or imprisonment or both.

TANGANYIKA

There is no general legislation in the Territory for the prevention of soil erosion, but preliminary consideration has been given to the enactment of an ordinance designed to protect public lands in the neighbourhood of railways and highways. Certain local measures, comprised within Native Authority and Cultivation rules are, however, in force. Such, for example, are the following :—

(1) No person shall cut trees or shrubs growing on hill tops.
(2) Before any individual may plant coffee, the land has to be prepared and approved shade provided to the satisfaction of the District Agricultural Officer or his nominee. In exercise of the rights conferred by the Native Authority Ordinance, all native authorities were authorized by the Governor in 1937 to issue orders "for the purpose of requiring the adoption of anti-erosion measures."

Some of the measures which may be prescribed by the native authorities are as follows :—

(1) Where cultivation takes place on ridges, the latter must be made on the contour principle, *i.e.*, across the slope of the hillside.
(2) Contour ridges by means of stone hedges or other suitable material should be constructed at suitable intervals, if cultivation is not done on ridges.
(3) Terracing.
(4) Storm water drains, ditches or pits.
(5) Tree planting to stop erosion by wind.

In certain districts the grazing of stock is prohibited in prescribed areas. In other districts the planting of crops, *e.g.*, coffee, or cutting of trees is forbidden in areas bordering rivers, springs, &c.

Any person contravening any of the provisions of the rules is liable to a fine or even imprisonment.

UGANDA

No soil erosion legislation is in force. A Government Agricultural Survey Committee recommended that special efforts be made with Government funds to adopt effective anti-erosion measures in specified areas. The work will be followed up with soil conservation propaganda among farmers.

2—J. N. 82595 (3/39)

THE ALL-CEYLON CATTLE SHOW OF 1939

ST. ELMO WIJEYEKOON

THE display of cattle at the show organized by the Cattle Breeders' Association of Ceylon on March 10 and 11, 1939, on the Ceylon Turf Club Grounds, came as a pleasant surprise to many people, and the large number and quality of the stock the country possesses were unexpectedly discovered.

In the opinion of those who had visited County and State cattle-shows in other countries, the main section of the show compared very favourably so far as the number, standard of the animals, site and management went.

Besides Ceylon cattle, that is, cattle of indigenous breed, there were breeds from India and the British Isles, and their crosses. The standard was creditably high, particularly that of the Government exhibits; and the existing drought, which had adversely affected the strength of the entries, was not reflected in the exhibits themselves. This fact is a recommendation to our cattle breeders, and proves that the breeds encouraged are generally suited to this climate.

Owing to a lack of variety in the exhibits—caused by the absence of previous experience of shows—many of the classes did not fill and had to be grouped together. Hence there arose the difficult situation of dairy and draught cattle being judged together. This anomaly was noticeable more especially in the Indian cattle section, with the result that the draught varieties which out-did the dairy breeds in numbers captured the judge's eye, and the dairy breeds—chiefly the Sindhi—failed to secure a single first prize.

The only classes which filled satisfactorily were some of country-bred Indian and cross-bred classes, which by reason of their numbers presented the judges with no easy task. Another difficulty which arose during the judging of the pure-bred classes and necessitated such remarks as "Kangayam × Hissar," "heifer apparently not pure Sindhi," "remaining entries all cross-breds" in the judging books was the presence of animals of doubtful origin in these classes. This denotes that most breeders do not exercise sufficient care in their work;

and that they fail to take steps to maintain the purity of breeds. A sure method would be to keep only one breed at each of their cattle-breeding centres.

There were 190 head of cattle at the show of which 77 were cross-breds. Indian cattle came second with 66 entries and Ceylon cattle took third place with 26 entries, while European and Australian pure-breds numbered 21.

THE EUROPEAN PURE-BREDS

In the pure-bred section, the best animals were found in the imported classes. Most of these belonged to the Department of Agriculture and were non-competitive exhibits. The country-bred pure animals were wanting both in quality and in numbers. This rather discouraging state of affairs may be explained thus :—

(1) The excessive demands of a climate of debilitation causes rapid deterioration of stamina and size. In the hands of the average breeder these deficiencies remain uncorrected for generations, or the strain dies off before it can make any useful contribution.

(2) The right breed from overseas for perpetuating its species in our climate has perhaps not been discovered yet. But with the breeds already under experiment, and the triple-purpose Red Poll given every chance, a useful conclusion should be in our hands before long.

(3) The prohibitive cost of importing fresh blood, and the comparatively poor return the private cattle-breeder derives, act as set-backs to individual enterprise.

Although imported cattle seem to have failed to enrich the country with pure climate-resisting stock, they have been used to advantage with Indian and local animals to provide hardy strains of cross-bred cattle for dairy and draught purposes.

THE GRAND CHAMPION A RED POLL

Queensland, in tropical Australia, provided the Red Poll cow acclaimed the best exhibit at the show. She is a worthy representative of an unsurpassed all-round breed.

The points which recommend the Red Poll are the following characteristics it possesses :—

1. Hardiness.
2. Strong foraging instincts.
3. Ability to withstand the most severe drought and other extremes of climate.
4. Docile and tractable nature and the absence of horns.
5. Good milk yields on the usual feeding rations, averaging over 6½ gallons of milk per day.

6. Milk contains an average butter-fat content of 4 per cent.
7. Quick fattening qualities.
8. Aptitude for draught purposes.

Is the Red Poll the European breed of the future ?

AYRSHIRES FORM STRONG SECTION

The Ayrshires on show, with a single exception, were Government exhibits, and were numerically the strongest of the dairy cattle in the European and Australian cattle section. The exhibits were shown in very good condition and attracted much attention. The most typical example of a milking cow, the Ayrshire vies with the Kerry for the reputation of being able to yield a good return of dairy produce on poor land and inferior food. Cows of this breed tend to put on too much flesh, which brings about a corresponding reduction in milking powers. The best preventive for tendencies of this nature is to arrange that heifers shall calve after the second year instead of after the third—the ordinary calving time of the breed. Then their milking powers are developed at the expense of the tendency to produce flesh.

FRIESIAN BULLS SHOW WELL

The Friesians—all bulls except one—made a fairly good show. While some of the exhibits were of a high quality, others disclosed traces of the results of crossing. These features were highly undesirable in the pure-bred classes. The Champion Friesian—an imported bull, 12 years of age—was a particularly fine animal of beautiful conformation and true to type: a good bull for the production of progeny with milking qualities. From the utility point of view this breed is the most favoured for its capacity for heavy milk yields; but the quality of the milk—at least as regards butter-fat—is often poor. In Holland, the average butter-fat content is reported to be below 3·5 per cent.; but the butter-fat content—as in other breeds—is capable of being raised by careful selection. Essentially a dairy breed, the Friesian has been shown by certain Scottish breeders to be able to take on beef-producing characteristics as well. The Friesian is the breed for good conditions. With our poor pastures and frequent droughts, preference should always be given to less exacting breeds, for the Friesian will certainly not answer the call for an all-rounder in any weather.

THE KERRIES IMPRESS

This Irish Cottar's breed is the "thorough-bred of Irish Cattle," and specimens were exhibited in fine condition by the Department of Agriculture. This breed was specially imported for experiments with black cattle of indigenous breed.

Cows of this breed give milk yields of about 2½ gallons per day with a butter-fat content varying from 4 to 5 per cent. In general outline, the Kerry has much in common with the Jersey or, for a matter of that, with the Ayrshire, though in size it is smaller than either. Its spare form indicates its superiority in milking rather than in beef qualities. This breed from Ireland crosses remarkably well with other breeds, and can exist on sparse conditions.

THE INDIANS

The second highest number of entries was recorded in the Indian cattle section which was composed of the following breeds—Hissar, Nellore, Sindhi, Kangayam, Gujerati and Montgomery.

The draught cattle in this section were a sturdy lot and did very well in annexing most of the prizes. The best country-bred Indian bull was a Nellore of outstanding quality. That all is well with the larger-sized draught Indian cattle in Ceylon is evident. But a further improvement in this direction can well be anticipated by the introduction of the Kangayam—a breed of powerful draught-cattle of moderate size. The only animals of this breed on show were those exhibited by the Department of Agriculture. These animals are constitutionally very sound, economical to maintain, and have been found to continue to last from 10 to 12 years in full working fettle. The Indian dairy-breeds were strongly represented by the Sindhi and Montgomery breeds. The best exhibits of the former, and the only exhibits of the latter, were those sent in by Government. Red Sindhi cattle are, comparatively speaking, small, compact animals—perhaps one of the reasons for their having missed the judge's eye in the open Indian classes. They are the most efficient milch-cattle of India; and are greatly in demand for milk production in the tropics. They produce excellent results when crossed with European breeds. The Montgomery, or Sahiwal, exhibited solely by Government is another future breed of Indian milch-cattle. The fact that they can exist in dry areas with poor pasture makes them well suited to this country. The bullock of this breed is useful for slow work, but, though not essentially a draught animal, it is reputed to make good as a fattener.

CATTLE OF INDIGENOUS BREED

In this section there were some good specimens of Ceylon cattle. Of considerable assistance to the judges were the fine specimens from the Government experimental station for indigenous cattle in the South. Here again there were some exhibits showing traits of crossing, and the process of elimination took up too much of the judges' time. For purposes of

improving the breed, the judicious infusion of Kerry blood seems highly desirable. But whatever methods are employed to grade up the Ceylon breed of cattle, the type—so ideally suited to rural requirements—must not suffer. All that the Kerry means to the Irish Cottar, the indigenous breed must mean to the Ceylon peasant. The champion exhibit in this section was a bull—" a very typical specimen of good colour, and very good head."

EXCELLENT SHOW OF CROSS-BREDS

The cross-breds turned up in full force, and made their section the most popular with 77 entries. There were such crosses as Sindhi, Ayrshire, Friesian-Sindhi, Poll-Ayrshire, but it is difficult to say which is the most popular, as many exhibitors were unable to state the exact details of the crosses. From inspection, one fact was evident—that the Sindhi and Ayrshire had done their bit in providing most of the animals in these classes.

Should this type of cross seem to suffer from the ill-effects of climate by over-much pure European qualities, a sure remedy is the infusion of new Sindhi blood, which will help in the grading up of stock while preserving the milking qualities.

This show has been a definite stimulus to cattle-breeding. Our aims to breed more and better cattle can be achieved only if this new interest leads to a more scientific idea of the business. In place of the more or less haphazard cattle-owning, strict attention should be paid to herd registering and recording, scientific feeding which involves pasture management and conservation of fodder, and the preparation for drought. The serious set-backs that so often hinder the progress of cattle-breeding are not occasioned by Nature's varying moods but by man's remissness.

(The opinions expressed in the above article are those of the author, and the Editor does not necessarily agree in all points.

For example, the statement that Red Polls as a breed average over 6½ gallons of milk per day would appear to require modification. A few selected cows can average over 6½ gallons under special conditions, but the general breed average is very much lower.

Ayrshire breeders would probably take exception to the statement that cows of this breed tend to put on too much fat.

The usual calving age for Ayrshire cattle in Scotland is between 2 years and 3 months and 2 years and 6 months.

The breeders of Sahiwal cattle in India would probably contest the claim that the Sindhis are the most efficient milch cattle in India.

There are other suggestions in the note to which the Editor cannot subscribe.—Ed. T.A.)

THE FERTILIZATION OF CITRUS TREES*

AS is the case with other varieties of plants, the substances that citrus trees need to carry on their existence are air, water, phosphoric acid, potash, lime, and to a lesser degree such minerals as magnesium, iron, sulphur, manganese, zinc, copper, &c.

Air is, of course, plentiful and free to all, but it is the only requisite of plant life that is. Water is a most important factor in the development of the plant, the greater portion of the living plant consisting of water. Water, moreover, by dissolving the plant foods contained in the soil, reduces these to a condition in which they can be easily absorbed by the roots of the plants. The action of water in making available large quantities of plant food is the chief reason for the increased fertility shown by soils in arid areas when they are irrigated.

Water, then, is the first requisite that must be added to the soil to promote plant growth, and as citrus trees require more moisture than do most other varieties of fruit trees, the first essential to successful citrus culture is an ample rainfall, or where this does not exist, then the land must be supplied with sufficient water by means of irrigation.

Of the various mineral ingredients contained in the soil phosphoric acid, potash, nitrogen, and lime are the ones taken up in the greatest quantities by the various plant varieties, including citrus trees, and as the consequent removal of these plant foods from the land through cropping will, in time, lead to the impoverishment of the soil, these substances must be replaced if the land is to remain in a fertile condition.

HUMUS

Besides their mineral ingredients practically all soils contain a greater or less amount of decayed organic matter, or humus, which is especially the case with virgin lands, which in their natural state are covered with forest, shrubs, or grasses. Humus, consiting of the elements, drawn from the air and soil, and having formed the substance of organic beings, is naturally rich in the ingredients required for plant life. A soil well supplied with humus is therefore a fertile one, and few of the higher classes of plants will thrive if humus is deficient in the soil.

Humus, moreover, is the home of the nitrifying soil bacteria. These bacteria have the property of taking up the nitrogen from the air that penetrates the soil into their own bodies, and thereby increasing the nitrate content of the soil.

The desirability of having a good supply of humus in the soil of the citrus orchard is therefore apparent.

* A Paper read at the Conference of River Murray Branches of the Agricultural Bureau, held at Berri on June 16, 1938.—By F. R. Arndt, Horticultural Adviser for the Upper Murray District of South Australia, in the *Department of Agriculture, South Australia, Bulletin* No. 335.

MANURIAL PRACTICES IN PAST YEARS

For many years the fertilization of the citrus grove was, to a great extent, a matter of guesswork, and a variety of manurial practices was practised by citrus growers. When considerable quantities of organic matter—generally applied in the form of stable manure—were given to the trees, fairly good results were generally obtained ; but the application of phosphatic or potassic fertilizers by themselves, or with small quantities of nitrogen very often gave only indifferent results.

In later years growers in applying larger quantities of nitrogen—often together with heavier dressings of other chemical fertilizers as well—generally found that the trees so treated made more vigorous growth and bore better crops than formerly, but were often at a loss as to which of the fertilizers the beneficial results so obtained were chiefly due.

It was not until the subject of the fertilization of citrus was thoroughly investigated at scientific research stations, chiefly in the United States of America and in Australia that the great value of nitrogen as a citrus fertilizer was definitely established, and the manuring of citrus trees placed on a sound basis.

CITRUS FERTILIZER TRIALS AT THE STATE EXPERIMENTAL ORCHARD AT BERRI

To test the value of various kinds of fertilizers in relation to citrus trees a series of manurial experiments was commenced at the Berri Experimental Orchard in 1920 with trees planted in 1911, and these trials, with some modifications, are still being continued.

These experiments have definitely demonstrated the overwhelming importance of nitrogen as a fertilizer for citrus trees, either by itself, or in conjunction with other fertilizers.

The land upon which the trees utilized in these experiments are planted consists of a light, deep, red sandy loam, typical of much of the soils of the Murray upland slopes, and has been classed as " Murray Sand " in the C.S. and I.R. Soil Survey of the Berri area.

The trees given over to these experiments are, with the exception of some off-type navels situated in the superphosphate fertilizer plot, of the Washington navel variety, and are planted at the rate of 99 to the acre.

The fertilizers were applied in two dressings, half quantity in spring and the other half in late summer. The first records in regard to yields were taken in 1921.

In the following tables the average annual acreage yields of the various fertilizer plots have been worked out from the data supplied by the manager of the Berri Experimental Orchard, Mr. O. E. Halliday, on the basis of 48 lb. to 1 bushel of fruit.

The results herein given have been compiled from the records taken up to the end of the 1937 season, and include a considerable amount of data that has not been previously published.

Each separate test has been confined to one row, or part of a row of orange trees, the rows running in the direction that the trees are watered.

SULPHATE OF AMMONIA FERTILIZER TESTS

The following are the records of the sulphate of ammonia fertilizer tests for the past 17 years :—

Sulphate of Ammonia Tests.

Row Number.	Number of Trees in Test.	Quantities of Fertilizer applied per Acre.	Average Annual Yield in Bushels per Acre, 48 lb. = 1 Bushel — Years 1921–1929, inclusive.	Average Annual Yield in Bushels per Acre, 48 lb. = 1 Bushel — Years 1921–1937 inclusive.
		cwt.		
3	16	1	69	137
4	16	2	103	138
5	16	3	192	228
6	16	4½	218	264
7	17	5	212	248
8	17	2½	186	206
9	17	No fertilizer	60	39

From the above figures it will be seen that with the exception of the no fertilizer plot, which showed a decline, all of the other sections increased their average annual production over the whole of the 17-year period of the experiment compared to that of the first nine years, which was, in great measure, probably due to the trees attaining greater age.

In these experiments no cover crops were grown among the trees or any organic fertilizers or other humus forming materials brought on to the land.

SULPHATE OF POTASH TEST

The records of the sulphate of potash tests for the nine years, 1921 to 1929 inclusive, are as follows :—

Sulphate of Potash Fertilizer Tests.

Row Number.	Number of Trees in Test.	Quantities of Fertilizer applied per Acre.	Average Annual Yield per Acre in Bushels, 48 lb. = 1 Bushel. Years 1921–1929, inclusive.
		cwt.	
10	16	1	46
11	17	2	101
12	16	3½	52
13	16	5	6[illegible]
14	17	2½	[illegible]

It will be observed that there is a considerable difference in the production of the various tree rows, no doubt due to one or more of several factors such as variations in soil conditions, situation or hereditary differences in the trees themselves, and the low average yields of rows 10 and 14 may, at least in part, be accounted for by the fact that the former is situated next to a " no manure " row, and to the latter being located alongside a row of almond trees.

In comparing the average annual acreage yields of the sulphate of ammonia and sulphate of potash plots with each other these show that those of the former are about two and three quarter times as great as those of the latter ; and even if Rows 10 and 14 are excluded from the calculations owing to their rather unfavourable situation, the average annual yield from the sulphate of

ammonia plot for the nine year period of the experiment is still more than twice that produced by the three remaining rows fertilized with sulphate of potash.

The exclusive use of potash had not been continued for more than a few years when there were indications that this fertilizer treatment was detrimental to the welfare of the trees. This became more and more apparent as time went on, the trees year by year decreasing in vigour, colour of foliage and productiveness.

At the end of nine years the health of the trees had declined to such an extent that the colour of their foliage had changed to a distinct yellowish shade, while such new growth as was made was weak and stunted.

The decline in the productivity of the trees during this period was likewise great, and had decreased to an average of 22 bushels per acre for the whole plot for the ninth year of the experiment.

The trees by this time had become so unthrifty that it was apparent that no further demonstration was needed to prove that potash by itself was unsuited for the successful culture of citrus trees (at least as far as conditions at the Berri Experimental Orchard were concerned) and it was decided to discontinue the experiments in that form, and by the addition of nitrogen to the fertilizer programme to carry out a new series of tests.

The six weakest of the trees, which were situated at the beginning of the irrigation runs, were excluded from these new series of experiments, as being too weak and stunted for further experimental work, but were still fertilized with potash, while another 21 trees were utilized in barrier rows. The remaining 55 trees were still given the same quantities of sulphate of potash as formerly, but were in addition supplied with nitrogenous fertilizers.

RESULTS OF TRIALS WITH MIXTURES OF POTASSIC AND NITROGENOUS FERTILIZERS

In the new trials each test row was divided into two portions, consisting of five and six trees each respectively, and each such section was fertilized either with 5 cwt. of sulphate of ammonia or with 7¾ cwt. of blood manure, besides receiving the same quantities of sulphate of potash as formerly.

These tests had not been in progress for more than a few years before a wonderful recovery was made by the trees, both in general health and in productiveness, and they soon attained the characteristics of normal, well-grown orange trees.

For the eight-year period that these new trials have now been in progress, the average annual acreage yields have been slightly better than those obtained in the sulphate of ammonia tests, while when compared with those secured when only potash was used, the records show an annual average acreage production almost four times as great.

The production records of the potash-nitrogen experiments are shown in the following table compared with the results obtained from the use of potash only.

Tests with Sulphate of Potash and Nitrogenous Fertilizers.

Row Number.	Number of Trees in Test.	Quantities of Fertilizers applied per Acre.	Average Annual Yield per Acre in Bushel Cases, 48 lb. = 1 Bushel.	
			Mixed Fertilizers, Years 1930–1937.	Potash only, Years 1921–1929.
Part 10 ..	5	.. 1 cwt. sulphate of potash, 7½ cwt. blood manure	77 ..	46
Part 10 ..	6	.. 1 cwt. sulphate of potash, 5 cwt. sulphate of ammonia	177 ..	46
Part 11 ..	5	.. 2 cwt. sulphate of potash, 7½ cwt. blood manure	241 ..	101
Part 11 ..	6	.. 2 cwt. sulphate of potash, 5 cwt. sulphate of ammonia	402 ..	101
Part 12 ..	5	.. 3½ cwt sulphate of potash, 7½ cwt. blood manure	284 ..	52
Part 12 ..	6	.. 3½ cwt. sulphate of potash, 5 cwt. sulphate of ammonia	238 ..	52
Part 13 ..	5	.. 5 cwt. sulphate of potash, 7½ cwt. blood manure	236 ..	64
Part 13 ..	6	.. 5 cwt. sulphate of potash, 5 cwt. sulphate of ammonia ..	269 ..	64
Part 14 ..	5	.. 2½ cwt. sulphate of potash, 7½ cwt. blood manure	222 ..	32
Part 14 ..	6	.. 2½ cwt. sulphate of potash, 5 cwt. sulphate of ammonia	168 ..	32

TEST WITH SUPERPHOSPHATE

Another series of trials regarding the productivity of orange trees was carried out by applying various quantities of superphosphate to different rows of trees.

As previously mentioned the plot given over to these experiments comprises a considerable number of off-type navel trees, which, however, are fairly evenly distributed over the various tree rows with the exception of Row 8, which consists entirely of good type navels, and so has here been omitted from these records as not yielding a fair basis of comparison with the other trees.

The land occupied by these trees is, with the exception of Rows 7, 9 and 10, hardly first class citrus land, and this, combined with the fact that many of the trees are not of the true Washington navel type, probably accounts for their low production during the 8-year period that these experiments were in progress.

The following are the records of these fertilizer experiments for the years 1921 to 1928, inclusive :—

Superphosphate Tests (Strength of Fertilizer = 36% Superphosphate).

Row Number.	Number of Trees in Test.	Quantities of Fertilizer applied per Acre.	Average Annual Yield per Acre in Bushel Cases 48 lb. = 1 Bushel, Years 1921 1928, inclusive.
		cwt.	
1 ..	9 .	1½ ..	33
2 ..	9 ..	3 ..	16
3 ..	10 ..	4½ ..	25
4 ..	10 ..	[illegible] .	28
5 ..	10 ..	8 ..	37
6 ..	10 ..	10 .	23
7 ..	9 ..	5 ..	90
9 ..	10 ..	6 ..	92
10 ..	10 ..	12 ..	93

The above figures show an exceedingly low rate of production, even when allowance is made for the type of the trees and the nature of the soil, and seem clearly to indicate that the application of superphosphate by itself is a most unsatisfactory fertilizer programme to follow in the manuring of citrus trees.

As was the case with the trees that were fertilized exclusively with potash, the trees on this plot also decreased in vigour and the colour of their foliage yellowed as time went on, but not quite to the same extent as those treated with potash alone.

TESTS WITH SUPERPHOSPHATE AND NITROGENOUS FERTILIZERS

After these experiments had been carried on for eight years it was apparent that the unsuitability of superphosphate as a sole fertilizer for citrus trees had been amply demonstrated. The trials were accordingly discontinued in their original form, and in 1930 were modified to include sulphate of ammonia and stable manure in addition to superphosphate.

In these new experiments the Rows 2, 4, 6 and 10 were utilized for the fertilizer trials, and the intervening rows used as barrier rows. Each fertilizer row was divided into two sections, with a barrier tree separating the sections, and in addition to superphosphate were fertilized either with sulphate of ammonia or stable manure.

The results of these experiments compared with those of the same test rows when these were fertilized with superphosphate only, are as follows :—

TESTS WITH 36 PER CENT. SUPERPHOSPHATE, SULPHATE OF AMMONIA, AND STABLE MANURE

Row Number.	Number of Trees in Test.	Quantities of Fertilizers applied per Acre.	Average Annual Yield per Acre in Bushels, 48 lb. = 1 Bushel.	
			Mixed Fertilizers, Years 1930–1937.	Superphosphate only, Years 1921–1928.
Part 2	3	3 cwt. superphosphate, 15 tons stable manure	99	16
Part 2a	4	3 cwt. superphosphate, 5 cwt. sulphate of ammonia	175	16
Part 4	4	6 cwt. superphosphate, 15 tons stable manure	328	28
Part 4a	4	6 cwt. superphosphate, 5 cwt. sulphate of ammonia	176	28
Part 6	3	10 cwt. superphosphate, 15 tons stable manure	216	23
Part 6a	4	10 cwt. superphosphate, 5 cwt. sulphate of ammonia	283	23
Part 10	4	12 cwt. superphosphate, 15 tons stable manure	390	93
Part 10a	4	12 cwt. superphosphate, 5 cwt. sulphate of ammonia	410	93

Little further comment is necessary upon this series of experiments, as the figures speak for themselves. The results obtained by the application of either sulphate of ammonia or stable manure are most striking and show that the yields per row were thereby increased from more than four to twelve times of those obtained when only superphosphate was used.

NET RESULTS OF BERRI CITRUS FERTILIZER TESTS

The results obtained in the citrus fertilizer trials of the Berri Experimental Orchard clearly show that nitrogen is a major limiting factor in citrus production, and that the application of potash and superphosphate by themselves is quite insufficient to provide the trees with the requirements necessary for their successful development.

Bulky organic fertilizers have only been used in connection with the four test rows in the reconstructed superphosphate plot, where stable manure, in addition to superphosphate, was applied; and for the 8-year period that these trials have now been going on the production of the trees under this test has been practically the same as those obtained from the adjacent test rows where sulphate of ammonia was used in conjunction with superphosphate.

There are indications, however, that on some of the fertilizer plots, which have now been under clean cultivation for over 20 years, the original supply of humus in the soil has greatly diminished, and that the trees would benefit by the addition of bulky organic fertilizers to the land.

CALIFORNIAN EXPERIMENTS

Extensive experiments in the fertilization of citrus trees have been carried on in California for a number of years on various experimental stations.

The results generally coincide with those obtained at Berri, but the experiments have been carried out on a much more extensive scale.

As at Berri, the Californian researches show that nitrogen is the limiting factor in citrus production, and that potassic and phosphatic fertilizers by themselves, or together, are of little use in promoting the productivity of citrus trees.

Considerable experimental work has also been done with organic fertilizers in bulky form, such as barnyard manure, lucerne-straw, or cover crops, and these have generally given better results than when only concentrated nitrogenous fertilizers have been used, but a mixture of these two kinds of fertilizers has been found to be the most effective with trees in full bearing.

The Californian researches indicate that citrus trees in full bearing under average conditions require from 2 to 3 lb. of nitrogen per tree per year, half of which should be supplied from bulky organic sources and the other half from chemical concentrates.

COVER CROPS

Whether the growing of cover crops among citrus trees is advisable or not is a matter that has often exercised the minds of many citrus growers.

With deciduous fruit trees and vines, which are dormant during winter, and which consequently take but little moisture from the soil at this time of the year, cover crops can be grown amongst these without causing them to suffer any ill effects from want of moisture; but with citrus trees the case is different, as these require that the land should be kept fairly moist during this period to enable them to fill out their fruit and to replenish the moisture lost by transpiration through their foliage.

Owing to the dry climatic conditions generally prevailing in the Murray districts, cover crops cannot be successfully grown in a normal season, even among deciduous trees and vines, without an autumn or winter irrigation, but in the case of citrus trees more waterings than this are often necessary, which makes the growing of cover crops a more costly one.

There can be little doubt that among young trees the practice is a beneficial one, as the tree roots are not, as yet, in full possession of all of the land, and the cover crops consequently do not compete unduly with the trees for plant food and moisture.

With older trees, however, from 10 to 12 years of age and onwards, the case is different, as these require more moisture than younger trees to carry on their normal functions, and the growing of cover crops among them may, in the absence of heavy rains or frequent waterings, dry out the soil to such an extent as to detrimentally affect the health and vigour of the trees.

Other disadvantages in the growing of cover crops among full grown citrus trees include—the detrimental effect of excessive shade, which often prevents the satisfactory development of the crops, even when the soil is well supplied with moisture; the inconvenience caused by the work necessary for the irrigation of the trees while the harvesting of the fruit is in progress; and the damage that may be done to the crops by the pickers when moving around and between the trees during harvesting operations.

BULKY ORGANIC MANURES

Owing to the difficulties experienced in the growing of satisfactory cover crops the most effective way in which to supply full grown citrus trees with humus and other fertilizing substances from organic sources is by bringing bulky organic manures on to the land.

These may consist of various kinds of animal manures, and of materials of vegetable origin, such as lucerne, bean straw, wheaten straw, and of other products of plant life.

The manurial value of the different organic substances varies considerably, especially in nitrogenous content, and allowances must be made for this in the fertilization of the citrus grove.

From information supplied by Mr. C. S. Piper, Chemist of the Waite Agricultural Research Institute, several years ago, it appears that the nitrogen in one ton of air dry tops of the kinds of the leguminous plants here mentioned is as follows:—Beans, 80 lb.; tares, 58 lb.; peas, 54 lb.; and lucerne, 53 lb. To express these amounts of nitrogen in terms of sulphate of ammonia, it is necessary to multiply by 5—sulphate of ammonia containing approximately 20 per cent. of nitrogen. Therefore the nitrogenous content of 1 ton of these dry plant substances is, in the case of beans, equal to 400 lb. of sulphate of ammonia; tares, 290 lb.; peas, 270 lb.; and lucerne, 265 lb. of that fertilizer.

STABLE MANURE

The manurial value of stable manure, which is the fertilizer of bulky organic form most often applied to citrus trees, has been variously computed to contain from 8 to 15 lb. of nitrogen, 6 to 12 lb. of potash, and 6 to 7 lb. of phosphoric acid per ton, the differences in these fertilizing properties being partly due to the nature of the fodders that the animals have been fed on, and partly to the condition of the manure when used.

Stable manure is generally applied to the land in a partly rotted form, but in the process of storing, carting and spreading often dries out considerably, with the consequent loss of some of the nitrogen in the form of ammonia.

If the nitrogenous content of manure at the time of ploughing in be computed to be one-half one per cent., then one ton of stable manure will contain about 11 lb. of nitrogen, which is equivalent to almost ½ cwt. of sulphate of ammonia, and if 10 tons be applied per acre (which may be considered a serviceable dressing), then the land will be enriched with nitrogen equal to that supplied by about 5 cwt. of sulphate of ammonia.

In addition to its nitrogenous content, the application of 10 tons of stable manure of average quality will supply phosphoric acid roughly equal to that contained in about 3 cwt. of superphospate, and potash equal to about 1½ cwt. sulphate of potash. Besides its direct manurial value, stable manure, in common with other bulky organic fertilizers when applied to the land, promotes conditions favourable for the development of the nitrifying soil bacteria, and in addition has the property of improving the physical texture of the soil and increasing its water holding capacity.

BALANCED FERTILIZER PROGRAMME

As nitrogen is the chief limiting factor in citrus production it is the fertilizer that has first of all to be taken into account when the fertilization of the citrus grove is being considered.

Allowing for 100 trees to the acre (which may be considered the average planting in the irrigation areas), and that the minimum requirement of nitrogen is 2 lb. per annum per tree in full bearing, then if half of this is to be supplied from bulky organic sources and half from concentrates, this may be obtained by the application of 9 tons of stable manure and 4½ cwt. of sulphate of ammonia. If it is desired to increase the supply of nitrogen to 3 lb. per tree the quantities of the above fertilizers must be increased by 50 per cent., but this should only be necessary with very large trees.

Where such large quantities of stable manure or other organic substances are difficult or costly to obtain, the greater portion of the nitrogen required by the trees must be obtained from chemical concentrates; but organic matter should be applied to the land whenever possible to keep up the fertility of the soil and the health of the trees.

As the Berri fertilizer trials tend to show that the application of nitrogen with either potash or superphospnate has given better results than those obtained from the use of nitrogen alone, it is advisable that these latter fertilizers should also be used if organic manures are not freely applied, but heavy dressings should not be necessary, and the application of about 3 cwt. of superphosphate annually, and from 1 to 2 cwt. of sulphate of potash every second year should be sufficient on most plantations. The importance of phosphoric acid and potash is at present under investigation.

For young trees not in bearing heavy applications of fertilizer should not be needed. Cover crops of peas or beans should supply most of the fertilizer they require, but light dressings of sulphate of ammonia at the rate of 1 to 2 cwt. per

acre may also be helpful at times. Where cover crops are not grown moderate dressings of stable manure or other organic matter should be applied to the land.

TIME AND METHODS OF APPLICATION

The best time to apply the greater portion of the fertilizer required for citrus trees is in late winter or early spring before the trees have commenced their new season's growth, so that it may be readily available for the production of new foliage and help in the flowering and setting of the fruit.

Stable, or other bulky manures, should be applied during the winter and ploughed in, so that they rot very quickly and their plant foods become available to the trees during spring and early summer. Such manures can either be distributed broadcast over the whole of the land before it is ploughed, or spread in one or more deep furrows along each tree row and then ploughed in. Compared with the one furrow method of application, broadcasting will result in a more even distribution of the roots of the trees, promote bacterial activity, and improve the texture of the soil, over a wider area, but where the manure is put into two or more furrows more uniform soil conditions will be established than when only one is used, and the tree roots will consequently not be so closely crowded together in obtaining their food supply.

The superphosphate, potash, and about half of the nitrogen concentrates should be applied just prior to or after the first irrigation in spring. The remainder of the nitrogen concentrates may be used in two equal dressings during December and February, or may be utilized by being applied in smaller quantities at each irrigation.

The concentrated fertilizers may be applied either by broadcasting and ploughing under, by scattering along the bottom of plough furrows, or by drilling with an orchard manure sower.

Broadcasting, although theoretically the best way to apply fertilizers, as every portion of the orchard is thereby evenly supplied, is in practice not always the most satisfactory method, for unless the land is very deeply ploughed and the manure turned well under, much of it will be placed too shallow for the roots to readily come in contact with it. This is especially the case with superphosphate, which does not leach very deeply nor spread very far from where it has been placed, even under irrigation conditions, and should consequently be put down deeply into the soil.

Concentrated fertilizers, to give best results, should act fairly quickly, and in this respect are different from bulky organic manures, which render available their fertilizing properties much more slowly; therefore if they are distributed by means of either manure sowers or by being placed at the bottom of plough furrows, they are put more deeply into the soil and so become more quickly available to the trees.

THE COLD STORAGE OF FRUITS AND VEGETABLES*

I. INTRODUCTION

THE term " cold storage " is applied to methods of storage at low temperatures generally produced and maintained by mechanical means. One of the earliest known methods of storage of perishable foodstuff was to keep it in a cave or cellar. Natural ice where it was available was also used for storing purposes. Modern mechanical refrigeration is a great improvement over such primitive methods and can be used in all countries under all conditions.

The Royal Commission on Agriculture in India made the following remarks in their Report (1928) :—

> " Cold storage is, in other countries, playing such a remarkable part in the marketing of goods, both for export and for internal consumption, with results so generally profitable to the private enterprise undertaking the arrangements as well as to the farmer, that we do not doubt that sooner or later there will be a similar development in India. We trust that those concerned will keep abreast with the research on the subject of cold storage which is being carried out in other countries, and will, when the time comes, prosecute in India any investigations required to adapt modern practice to local conditions." (Page 408.)

The Imperial Council of Agricultural Research at an early stage of its existence took up this question and decided to locate its first cold storage research station at the Ganeshkhind Fruit Experiment Station, Kirkee, near Poona, in the Bombay Presidency. The Bombay Government had already in 1930 put up preliminary proposals for such work and was accordingly invited to put up further proposals which after being duly examined by the appropriate Sub-Committee of the Advisory Board of the Council, by the Advisory Board itself and by the Governing Body, were sanctioned as from March, 1934, for a period of three years at a cost of Rs. 90,154. The scheme was extended for a further period of three years at an additional cost of Rs. 50,188.

II. THE COLD STORAGE PLANT AT THE GANESHKHIND FRUIT EXPERIMENT STATION

Acknowledgments are due for the great assistance received from staff of the Low Temperature Research Station, Cambridge, in planning cold storage equipment. The workers in this institution gave Dr. G. S. Cheema, who had been given an Empire Marketing Board Scholarship to study cold storage methods, every possible assistance.

* By G. S. Cheema, D.Sc., I.A.S., and D. V. Karmarkar, M.Sc., Ph.D., A.I.I.Sc., of the Cold Storage Research Scheme, Kirkee, in *The Imperial Council of Agricultural Research, India, Miscellaneous Bulletin* No. 23.

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The refrigerating machinery was supplied by Messrs. J. & E. Hall, Ltd., of Dartford, Kent, England, and the construction work was supervised by the Agricultural Engineer to the Government of Bombay Presidency. The refrigerating plant consists of an ammonia compressor (5 H.P.) which is run by electric power. The evaporator coils cool down the brine in the brine tank which is circulated in the different chambers. There are seven chambers, each $10 \times 9 \times 8$ feet, and, in addition, there is a sufficiently wide (3 feet) air-lock corridor in front of the chambers. Cork slabs have been used as insulation in the construction of the walls, the floor and the ceiling of the cold chambers. Each chamber is fitted on one side with a wooden diaphragm which shields the cooling pipes carrying the cold brine. At the upper end of the diaphragm there is fitted an electrical fan (1 H.P.) of the propeller type, for air circulation. A thermograph is placed in each chamber to record temperatures on a weekly chart. Suitable wooden racks, 2 feet wide and of a total running length of 90 feet, have been fitted in each chamber for keeping the trays and boxes of fruit and vegetables for the experiments. "Day-light" electric lights have been provided in each chamber so as to get a better idea of the colour of the fruit.

The whole plant is fully automatic. Each chamber is fitted with a thermostatic switch which automatically turns on the brine circulation and, with it, the fan for the circulation of air in the chamber, when the temperature of the chamber gets higher than the temperature to which it is regulated. The brine circulation and the fan are automatically turned off when the regulated temperature is attained. The brine temperature is also automatically controlled. The compressor starts working as soon as the temperature of the brine rises above the regulated range and it stops when the brine is cooled down to the required temperature. A stand-by compressor and a brine pump have been provided in order to prevent any stoppages in case of a breakdown of the compressor or the brine pump.

III. IMPORTANT FACTORS INVOLVED IN COLD STORAGE

It was the object of these investigations to obtain practical data regarding the conditions under which Indian fruits and vegetables should be handled in cold storage and transport, to ascertain what varieties are most suitable for commercial storage and what results may be expected under reasonably favourable conditions. There are reasons to believe that, given such fundamental data, commercial enterprise will be willing to step in and develop a trade which has obvious possibilities. In consequence attention has been devoted mainly to the biological aspect of the problem.

1. Temperature

The question of temperature is, of course, of the greatest importance. A fruit or vegetable is a living organism which respires, taking in oxygen and

giving out carbon dioxide. In cold storage the " life " of the produce is extended, because the low temperature slows down the life processes going on in the fruit or vegetable and also retards the development of the micro-organisms which are responsible for the decay. The low temperature must not put a stop to the life processes but only retard them. It is, therefore, wrong to suppose that the lower the temperature the longer the " storage life " of the produce. The possibility of low temperature breakdown and freezing injury sets a limit to this. For every kind of fruit or vegetable there is a certain range of temperatures suitable for its storage which must be determined by experiment. Variations of two or three degrees above or below a desired temperature are often too much and must be avoided.

2. Humidity

In addition to the temperature, the humidity in a storage chamber is also very important. If it is too low, wilting is likely to occur in most fruits and vegetables. If it is very high, a condensation of moisture on the produce is possible, as a result of fluctuations in the temperature. It has generally been observed that a humidity of 80 to 90 per cent. gives the best results. Various methods have been proposed or tested from time to time for the control of humidity in cold storage chambers, but accurate control of humidity is rather difficult. It has, however, been found by experience that, when the storage chamber is filled with fruits or vegetables, a suitable humidity, between 80 and 90 per cent., is usually obtained. If it is found necessary to increase the humidity, this can be done by keeping the floor moist or by exposing shallow basins of water in the chamber. For decreasing the humidity a drying agent such as calcium chloride may be used.

3. Composition of the Air in the Chambers

The ordinary air of the atmosphere contains roughly 79 per cent. of nitrogen and 21 per cent. of oxygen with traces of carbon dioxide and water vapour. The fruit or vegetable in storage respires and gives out carbon dioxide gas at the expense of the oxygen in the air. The percentage of carbon dioxide is found to increase steadily in a cold storage chamber which is air-tight. The amount of carbon dioxide in the atmosphere of storage chambers has been found greatly to influence the " storage life " of the fruit. The presence of carbon dioxide up to a certain concentration in the storage atmosphere has been found to be beneficial and the new method of gas-storage, requiring careful control of the composition of the air of the storage chambers, has recently been developed. Higher concentrations of carbon dioxide have been found to be harmful. In a cold store, the usual proportion of nitrogen and oxygen is maintained by preventing an accumulation of appreciable amount of carbon dioxide. This is accomplished by opening the doors at the time of the examination of the stock or at the time of loading or unloading. In some cases artificial ventilation is resorted to and in others the air is completely changed at regular intervals.

4. Changes observed during Storage

In storage, there is a constant evaporation of water from the surface of the produce, the extent of which depends on the nature of the produce, the

temperature and the relative humidity of the storage chamber. Along with the evaporation of water there is a continuous process of respiration going on in the produce which consumes certain substances present in the fruit or vegetable. The united effect of these two changes results in a loss in weight of the produce. As a result, the produce in some cases may show wilting or shrivelling.

There are three causes by which the fruit or vegetable in cold storage is rendered unsuitable for consumption, *i.e.*, by chilling, physiological breakdown or fungal rotting. The symptoms of chilling are usually (1) change in colour, (2) development of pits or sunken areas on the skin and (3) in the case of fruit, failure to ripen properly. Physiological breakdown is an internal change of the fruit or vegetable and is usually not recognizable from the outside. The pulp is affected and, in some cases, dark brown areas develop. In others, internal fermentation sets in, giving the pulp a fermenting and bitter taste. Fungal rotting is visible by the development of dark brown areas on the skin or the appearance of the coloured fructifications of the fungus associated with a softening of the tissues.

5. Selection of Fruit for Cold Storage

Even in ordinary storage all the varieties of fruit do not behave equally There are some which are classed as "good keepers" and others as "bad keepers". In cold storage too, all the varieties do not keep well equally but differ in their cold storage behaviour. It is never certain that the "good keepers" in ordinary storage will be so in cold storage as well. It is possible that the "bad keepers" in ordinary storage may be "good keepers" in cold storage. For the successful cold storage of the produce it is, therefore, necessary to carefully study the behaviour of a number of commercial varieties of one kind of fruit in order to select the varieties suitable for cold storage.

It has been found that the cold storage behaviour of the fruit of a variety depends on the locality of its production, the age of the tree and cultural treatment. The storing quality of the fruit of a particular variety from one and the same locality may also vary according to the time of picking.

The stage of maturity or development of the fruit at which it is plucked off the tree is very important. Successful cold storage largely depends upon the fruit being obtained at the right stage of maturity. Although immature fruit may possibly keep the longest in sound condition, it may shrivel and may not attain perfection as regards colour, texture, taste and aroma. On the other hand, if the fruit is fully mature or ripe and soft, it may be chilled at the low temperature of storage or may only be kept for a short time in good condition. It follows that a stage of maturity between these two extremes, ensuring a good quality and long storage life should be determined experimentally by storage trials.

6. Treatment of Fruit before Storage

Fresh fruit intended for cold storage must be free, as far as possible, from skin breaks, bruises and decay. Even if the injured fruit could be kept in cold storage for a time without immediate decay, rapid deterioration is bound to take place as soon as it is removed to ordinary temperatures. Careful selection of the fruit is, therefore, necessary.

In some cases pre-storage treatments, such as washing the fruit with a disinfectant fluid, may lead to a reduction of rotting. In others wrapping the fruit with different kinds of paper may be advantageous. The method of packing, the type of package to be used, the nature of material to be employed in packing and the way in which the packages are stacked in a cold store are factors which must also be examined.

IV. RESULTS OF THE COLD STORAGE INVESTIGATIONS

The investigations were started in March, 1934, and the results obtained until now have been summarized below. The investigations on the storage of the mango have been made in detail and the influence of the important factors mentioned previously has been studied. The investigations on the orange are not yet complete. Preliminary storage trials on a few other kinds of fruits and vegetables have also been carried out.

1. Mango

It is of interest to note that Alphonso mangoes have been successfully shipped to England, in varying quantities and with varying results since 1932.

(a) *Temperature.*—The range of temperature found suitable for its storage was from 45° to 48°F. 43°F. was too low for satisfactory storage. The fruit was chilled at temperatures below 45°F. and the green unripe fruit did not ripen satisfactorily when removed to 68°F. or to room temperature, after storage. Pitting of the skin was very severe at low temperatures and the fruit rotted when removed to room temperature. At temperatures higher than 48°F. wastage was rapid. There was a development of bright yellow colour in fruit ripened at 68°F. and this was more marked in the fruit of varieties, such as the Peter, Pyree, &c., which normally do not develop a good colour.

(b) *Humidity.*—The relative humidity was maintained between 80 and 90 per cent. and has given good results. The effect of varying degrees of humidity has not yet been investigated ; its study has been postponed to a later date.

(c) *Stage of maturity.*—The ripe yellow fruit (eating maturity) of all the varieties investigated, except Fazri Zafrani and Kolanka Goa, turned brown in cold storage at 52°F. and the lower temperatures. The green unripe fruit which was just mature (the so-called " A " stage) was not suitable for cold storage, as it shrivelled and did not develop a sweet taste. Unripe fruit, fully mature and just showing faint signs of a change of colour (" C " stage), was chilled in cold storage and partially developed a brown colour. Fruit which was properly developed and yet green and hard (" B " stage) was found very satisfactory for cold storage.

(d) *Variety.*—There are innumerable varieties of mango grown in India. A few varieties which are famous in the different provinces in India were tried in cold storage. In all, twenty-eight different commercial varieties of mango from the Madras Presidency, the United Provinces, Bihar and the Bombay Presidency, were tested. Some of the varieties included in the storage trials were Peter, Suwarnarekha and Banganpalli from the Madras Presidency, Langra, Jardalu and Hemsagar from Bihar, Benarsi Langra, Fazri Zafrani and Fazri White from the United Provinces, Alphonso, Pyree, Shendrya, Batli and Fernandez from the Bombay Presidency.

The Alphonso variety, which is superior in ordinary storage, also led in cold storage as it was found to be the best keeper. The fruit of B stage of maturity could be kept at 45° and 48°F. for seven weeks in good condition and could be ripened afterwards satisfactorily. The maximum storage life of the fruit was about nine weeks at 45°F.

The fruit of the varieties Peter, Fazri Zafrani, Pyree and Cawasjee Patel, could be also kept in good condition for varying periods. The fruit of the Peter, Pyree and Cawasjee Patel varieties could be kept for four weeks at 48°F., seven weeks at 45° to 48°F., and nine weeks at 45°F. respectively. Though the fruit of the last variety showed good keeping quality, it is of an inferior type for table use. The ripe fruit of Fazri Zafrani could be kept in good condition for five weeks at 43° and 45°F.

The ripe fruit of the Langra and Jardalu varieties is very sweet. The market value of this fruit was lost as the colour of the skin turned brown in cold storage. The pulp of the fruit was not affected and the fruit could be preserved for the sake of its sweet pulp for six weeks at 43° and 45°F.

Further investigations were carried out on the fruit of the Alphonso variety. It was found that the unripe fruit when transferred to room temperature after cold storage ripened perfectly and developed the normal percentage of sugars. The rate of ripening of the fruit, however, slackened as the length of the storage period increased. The aroma of the Alphonso fruit was lost to a certain extent in cold storage.

The size of the fruit has been found to be of little importance as far as the storage quality is concerned. Both the big and the small-sized fruit of the same stage of maturity behaved similarly. But it is better for commercial purposes to have in one package fruits of uniform size as far as possible. The fruit having a portion of the stalk-end attached to it after being plucked has no advantage in storage life. The fruit with a short stalk-end is, however, preferred as it gives a cleaner and brighter appearance. The gum oozing out from the broken stalk-end is sticky and developes brown spots on the fruit in cold storage. There is no objection to store the fruit with the stalk-end broken off, as long as it is clean.

Most of the decay of the fruit was due to a fungus (*Gloeosporium mangiferae*), which appeared as stem-end rot, lateral rot, watery rot and " brown patches". Different pre-storage treatments such as washing with antiseptic solutions or smearing with antiseptic powders were of no advantage. It appears that the fruit with high acidity keeps longer than the fruit with low acidity. Apart from chilling, the only physiological breakdown is darkening of the pulp around the stone which was observed in every variety usually after nine weeks at 45°F. At the higher temperatures this development was found earlier.

The storage behaviour of the fruit of the Alphonso variety obtained from the five localities, Ratnagiri, Poona, Thana, Surat and Dharwar, well-known for the cultivation of this fruit in the Bombay Presidency, did not show a marked difference except that the fruit from Dharwar was inferior in keeping quality. The fruit from Ratnagiri remained green and hard for a longer period in cold storage as compared with the fruit from the other localities.

Wrapping the fruit individually either with tissue paper or waxed paper impaired the ripening power of the fruit after cold storage and the fruit when unwrapped quickly rotted at room temperature. Packing material like rice straw and wood-wool did not affect the fruit while in cold storage but vitiated the subsequent ripening to a certain extent.

A wooden crate of the size of 24 in. × 12 in. × 12 in., capable of holding about a hundred mangoes, was found to be a suitable kind of package for commercial cold storage. As wrapping the fruit individually was found to be harmful and as packing materials, like rice straw and wood-wool, affected the ripening of the fruit, wrapping of the fruit and packing it tightly with the packing material should be avoided, using only a light wadding of the packing material to hold the fruit in position and minimize bruising. The arrangement of the crates inside a cold chamber must be so planned as to ensure a good circulation of air and a uniform temperature.

Summary of Results regarding Cold Storage of Mangoes

(1) So far as these experiments have gone, the best varieties of mangoes for cold storage are, in order of merit :—

The Alphonso from Bombay, Pyree, Cawasjee Patel from Bombay, Peter from Madras, Fazri Zafrani from the United Provinces.

(2) The best stage of maturity for preserving the Alphonso Mango is the so called B stage, *i.e.*, when the fruit is full sized and just before it begins to turn yellow.

(3) At a temperature of 45°F. (with a variation not above 48°F.) the Alphonso variety can safely be kept in good condition for seven weeks and can be ripened satisfactorily afterwards. The maximum storage life may be as much as nine weeks.

(4) Mangoes for storage should be clean and free from gum-oozing from broken stalks. It is absolutely unnecessary to wash with antiseptic solutions or use antiseptic powder while paper wrappers definitely impair the ripening of the fruit after cold storage.

2. Orange

Cold storage trials of Nagpur oranges (the *Santra*) from the Central Provinces and of Malta oranges from the Punjab were carried out.

(*a*) *Nagpur orange.*—The green fruit did not ripen at 35°F. and 40°F. but became wilted and, after a period, assumed a brown colour and began to break down from inside. The fruit changed to a good yellow colour at 45°F. and 52°F. but by the time this change took place, most of the juice was lost.

Yellow oranges (fully ripe) kept their good outward appearance at temperatures from 35° to 52°F., but at the temperatures of 45° to 52°F. the inside pulp dried up quickly. At 35°F. the fruit could be kept for about two months but, on storage for a longer period, internal breakdown took place, the juice tasting bitter.

The yellow fruit and the fruit which was fully ripe but had not completely changed its colour could be kept in good condition for three months at 40°F. without any appreciable wastage. If the fruit was quite sound without an

injury to the skin there was practically no loss due to the growth of blue or green mould. There was, however, a little wastage due to *Alternaria* disease in which case the fungus grew inside and the black mass enveloped the entire pulp.

Wrapping the fruits individually with tissue paper was not of any great advantage but was useful in keeping the sound fruit out of contact with any rotting fruit. Pre-storage treatments, such as washing with borax, were found to be of no advantage, but in some cases definitely harmful.

As the fruit is loose skinned, there is a danger of the fruit being pressed down in a crate under the weight of the upper layers and thus of cracking the skin. In selecting the size of the crate and in packing, care should be taken that the fruit is not too much pressed.

(*b*) *Malta orange.*—Malta oranges which have fully developed the orange colour could be kept at 40°F. for four months in good condition without any wastage. The fruit could also be kept at 35° and at 45°F. in good condition but for a shorter period. The size of the fruit is very important in cold storage. Fruit of big size remained quite firm and also retained the original colour while the fruit of smaller size shrivelled and changed to a dull colour.

When the fruit was carefully selected there was practically no loss due to fungi. Only a few fruits partially changed the colour of the skin to brown and the skin became leathery. There was no particular advantage in wrapping the fruit individually with tissue paper. There is not much difficulty in packing the fruit in a crate as the skin is quite rough and does not easily break.

Summary of Results regarding Oranges

1. So far as these experiments have gone, the best oranges for cold storage are, in order of merit :—

(1) Malta oranges.

(2) The Nagpur orange (*Santra*).

2. The best stage of ripeness for storing oranges is—Malta oranges—when they are full sized and have fully developed the orange colour. For the Nagpur orange the fruit should be full sized and fully ripe.

3. At 40° F., Malta oranges will keep for four months and Nagpur oranges for three months.

4. If fruit is unjured there is no deterioration in cold store. Pre-storage treatments, such as washing with antiseptics or wrapping with papers, are of no advantage.

3. Other Fruits and Vegetables

Only preliminary storage trials of the following have been made :—

Peaches.—Peaches of the varieties, Elberta and 6 A, grown in the North-West Frontier Province could be kept in good condition for a month at 35°F.

Bananas.—The bananas of two varieties from Madras, Sirumalai and Karpura Chakkarakeli, ripened normally at 56°F. and could be kept for two weeks while the fruit of another variety, White Chakkarakeli, remained in good condition for about four weeks at 56°F. though the appearance was not very satisfactory.

The bananas of the Basrai variety from Poona got chilled at 56°F. and could not be ripened properly when kept at a higher temperature. The fruit ripened normally at 60° and 68°F. and was in good condition for three weeks at 60°F., and for two weeks at 68°F. The fruit of this variety did not get a good colour when ripened in the ordinary way, but storage at 68°F. developed a good yellow colour on the fruit.

Chikoo (Achras sapota).—The unripe fruit received from Baroda was chilled at 45°F. and the lower temperatures and could not be ripened after storage when removed to room temperature. The fruit ripened normally at 52° and 56°F. and remained in good condition for four to five weeks.

Litchi.—The ripe fruit from Bihar could be kept in good condition for three months at temperatures from 30° to 45°F. It could be kept even longer at 35°F. The red colour of the fruit, however, turned brown in storage and the shell became harder.

Apples.—Four varieties of apples from Chaubattia, *viz.*. Delicious, Jonathan, Stummer Pippin and Norfolk Biffin, were tried. The variety Delicious was found to be the best keeper, as the fruit was in very good condition even after eight months of storage at 32°F. The apples of the varieties Jonathan and Norfolk Biffin could be kept at 32°F. for about eight months without rotting, but the fruit shrivelled very badly. The fruit of the Stummer Pippin variety showed internal breakdown after four months.

Lemons.—Eureka lemons received from Sind could be kept in good condition at 40°F. for two months.

Potatoes.—It was found that seed potatoes of Khabrar and Garhwal varieties received from the Kumaon Hills, Mahableshwar Hill potatoes and the potatoes from Khed (near Poona) remained in dormant condition at 35°F. for about a year and the germinating power of the seed tubers was not much affected even after ten months of storage at 35°F. The relation of the temperature and the period of storage to the yielding capacity has not as yet been tested. For table use the Khed potatoes could be kept for about six months without sprouting at 40°F. The tubers sweetened at the lower temperature of 35°F.

Cabbage.—Cabbage (variety, Large Drumhead) could be kept at 32°F. for about six months in good condition. When stored for a longer period the development of a pale yellow colour on the inner leaves took place. The loss in weight during the storage period was about 35 per cent. when stored in open trays and less if stored in crates. " Solid " heads of cabbage kept better than the " loose " heads.

Cauliflower.—Cauliflower (variety, Early Snowball), if stored without any wrapping, did not keep in good condition even for a week at 32°F., but shrivelled very badly. The cauliflowers when wrapped in waxed paper or in their own leaves could be kept in a satisfactory condition for about two months at 32° and 35°F.

French beans.—French beans (local) could be kept in good condition at 32°F. or 35°F. for three weeks. The temperature should not be allowed to fall below 32°F. as the beans appear " blanched " and are quickly overgrown with fungus.

Peas.—The garden peas of Poona variety (in pods) could be kept at 32° or 35°F. for four weeks. It was necessary to store the peas in thin-mesh gunny bags in order to avoid the heavy loss of water from the pods. The temperature should not be allowed to fall below 32°F. in order to prevent freezing.

Carrots.—Carrots (country variety) could be kept at 32° and 35°F. for about three months in good condition but the tips dried and a fungal growth developed on storage for a longer period.

Onions.—" Young " onions remained in good condition for about two months at 32° and 35°F. Fully developed onions of both the red and the white country varieties could be kept without sprouting at 32°F. for more than six months. Generally the white onions appeared to be a little inferior to the red onions in storage quality.

V. PRE-COOLING AND TRANSPORT

To enable fruit to be brought from distant stations special experimental refrigerated containers have been made for the safe transport of the experimental material The containers are insulated boxes, weighing about 115 lbs., and are refrigerated with water ice. If the container together with the fruit is pre-cooled and then a charge of ice is given, a temperature of about 40° to 45°F. can be maintained during the transit period. The difficulty has been the total absence of any pre-cooling facilities at the places from which the fruit is obtained for the experiments. The containers charged with ice without pre-cooling give a temperature range of about 65° to 70°F. which is about 20–25° lower than the atmospheric temperature. It was possible to obtain litchis in good condition for cold storage trials from Bihar by using such a refrigerated container for their transport. Ordinarily the fruit is spoilt in transit. For the transport purposes it is really necessary to pre-cool the produce.

Cold storage and refrigerated transport go hand in hand. Even when the produce can be satisfactorily stored, it is necessary to have suitable arrangement for its distribution at reduced temperatures without which the main object of cold storage in extending the area of distribution and in creating new markets cannot be fully achieved.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED MARCH 31, 1939

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1939	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Blackquarter	1	..	1	..	..	..
	Rabies	1	..	..	..	..	1
	Piroplasmosis	2	2	..	..	2	..
	Rinderpest	9	9	..	2	..	7
Colombo Municipality	Foot-and-mouth disease	25	10	2	22	..	1
	Anthrax	..	..	..	..	..	..
	Rabies	..	..	..	..	..	..
	Piroplasmosis	3	1	..	3	..	..
Cattle Quarantine Station	Foot-and-mouth disease	1	1	..	1	..	..
	Anthrax	26	12	26	..	..	..
Central	Foot-and-mouth disease	79	39	..	46	33	..
	Anthrax	1	..	1	..	..	..
	Rabies	7	3	2	..	..	5
	Contagious mange	12	6	..	4	8	..
	Piroplasmosis	5	..	1	4	..	..
	Blackquarter	8	7	8	..	..	..
Southern	Foot-and-mouth disease	..	..	..	..	..	..
	Rabies	1	1	..	..	..	1
Northern	Foot-and-mouth disease	130	21	7	123	..	..
	Rabies	..	..	..	..	..	..
Eastern	Foot-and-mouth disease	2	..	..	2	..	..
North-Western	Foot-and-mouth disease	122	112	1	46	75	..
	Goat Pox	..	..	..	..	..	..
	Haemorrhagic Septicaemia	..	..	..	..	..	..
	Piroplasmosis	..	..	..	..	..	..
	Contagious mange	..	..	..	..	..	..
	Rabies	1	..	..	..	..	1
North-Central	Foot-and-mouth disease	1,287	11	..	1,276	11	..
	Blackquarter	..	..	..	..	..	..
	Haemorrhagic Septicaemia	..	..	..	..	..	..
Uva	Foot-and-mouth disease	58	58	1	42	15	..
	Rabies	..	..	..	..	..	..
	Blackquarter	..	..	..	..	..	..
Sabaragamuwa	Foot-and-mouth disease	..	..	..	..	..	..
	Haemorrhagic Septicaemia	1	..	1	..	..	..

A. JAYASINGHA,
for Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

Department of Agriculture,
Peradeniya, April 19, 1939.

METEOROLOGICAL REPORT, MARCH, 1939

STATION	TEMPERATURE Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	HUMIDITY Day	Night (from Minimum)	Amount of Cloud	RAINFALL Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	89·0	+1·4	73·2	–0·7	64	90	4·2	3·39	6	– 1·48
Puttalam ..	91·2	+1·8	72·5	0	66	90	4·4	1·36	4	– 1·97
Mannar ..	90·2	+0·6	74·7	–0·5	67	88	5·0	0·27	1	– 1·45
Jaffna ..	89·0	+0·7	75·2	–0·3	67	86	2·6	0·10	1	– 1·73
Trincomalee ..	85·4	+0·3	75·3	–1·2	74	91	2·8	1·20	4	– 1·16
Batticaloa ..	85·8	+0·6	74·8	–0·2	74	90	2·7	0·25	3	– 3·10
Hambantota ..	86·8	+0·2	73·8	–0·2	72	88	3·6	5·23	8	+ 1·40
Galle ..	86·0	–0·4	74·9	–0·1	74	88	4·3	1·82	7	– 4·39
Ratnapura ..	93·7	+2·0	71·7	–0·8	64	93	4·3	8·09	20	– 2·86
Anuradhapura ..	92·9	+2·5	68·6	–3·1	58	95	3·0	0·60	4	– 3·04
Kurunegala ..	95·6	+3·9	71·1	–0·7	49	93	5·2	4·90	10	– 1·08
Kandy ..	91·9	+4·6	67·4	–1·2	54	87	2·6	2·57	5	– 3·26
Badulla ..	82·3	+0·4	62·6	–1·8	61	94	3·4	2·79	7	– 2·78
Diyatalawa ..	79·4	+2·7	57·0	–1·1	54	80	4·8	2·51	9	– 2·44
Hakgala ..	75·3	+3·2	50·5	–1·7	65	81	4·2	1·81	6	– 4·89
Nuwara Eliya ..	72·2	+1·8	44·1	–2·5	52	85	5·0	1·56	8	– 2·76

Drought conditions continued into March, and the rainfall for the month was in deficit nearly throughout the Island, excesses being confined to less than 20 stations irregularly distributed. The largest excess was 5·64 inches at Keenagahaella, while excesses of 2–5 inches were reported from Mahawalatenna, Kumbukkan, Pelmadulla and Buttala. An appreciable number of stations, mainly on the lower western slopes of the hills, and in the adjoining low-country, recorded deficits of over 5 inches for the month, the largest deficits being 9·95 inches at West Haputale and 9·04 inches at Uggalkaltota.

The highest monthly totals were 17·21 inches at Keenagahaella, 14·18 inches at Mahawalatenna, and 12·13 inches at Pelmadulla, while seven other stations, mainly in the same area, recorded totals of over 10 inches. Nearly all the stations in the northern half of the Island recorded less than 2 inches for the month, an appreciable number, mainly in the Jaffna Peninsula and southwards towards Trincomalee, reporting no rain at all for the month.

Only one daily fall of over 5 inches was reported during the month, 5·10 inches at Galagoda, on the 14th.

The weather during the first two-thirds of the month was predominantly dry, such rains as occurred being generally light, and chiefly as a result of thunderstorm activity. An appreciable increase of rainfall occurred on the 22nd and the two succeeding days, due to increased thunderstorm activity. After three days of diminished rainfall, it increased again on the 28th, and weather conditions continued wet over a large part of the Island, chiefly in the southern half, till the end of the month. On the 31st the rain was fairly heavy at many places. Thunderstorm activity was well in evidence during the last third of the month.

Day temperatures were above, and night temperatures below normal. Humidity and cloud were both generally in deficit. The barometric pressure was also below normal. The wind, on the whole, showed no marked deviations from normal strength, while its direction was variable.

A hailstorm was reported on the 2nd from Hiniduma, and another on the 28th from Maliboda Estate, Deraniyagala.

H. JAMESON,
Superintendent, Observatory.

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EDITORIAL

MAN VS. BEAST

THERE has been much propaganda in recent years calculated to stimulate public interest in the preservation of wild life. Publicity has been given to the views on this subject of both local sportsmen and visitors to the Island. The correspondence columns of the daily papers have been used to ventilate the indignation of those who are shocked by what they call the indiscriminate slaughter of animals. Finally, a recent advertisement of the Tourist Bureau painting the attractions of Ceylon to the visiting sportsman has provoked a chorus of unqualified condemnation.

While the importance to science of the prevention of every species of animal from becoming extinct, or even of its preservation in natural conditions, is undeniable, there is an aspect of this problem which does not appear to receive sufficient notice from the un-imaginative town-dweller, but is of vital importance to the inhabitants of the village in the jungle and to the officers of Government who are engaged in the uphill task of raising the villagers' standard of agriculture. The whole story is epitomized in the following sentence extracted from a report of one of these officers :— "The villagers expected a good harvest but wild elephants destroyed the standing crop last night." This conveys nothing more than the loss of a couple of hundred bushels of paddy valued at as many rupees to the townsman who makes an annual pilgrimage to the jungle accompanied by his shikari and armed with a couple of very efficient rifles and a shot-gun and returns home with a few trophies, photographs of the "unspoiled" life of the primitive village and stories of hair's-breadth escapes from death by floods, snakes, or the charge of infuriated elephants. He will write letters to the papers protesting against the commercial exploitation of the man-eating crocodile so long as it is the other man's wife and the daughter who go to the crocodile-infested tank to bathe and to bring home the pot of drinking water. But he would do well to give some thought to the peasant's point of view.

The peasant of the jungle village lives perilously near the starvation level. He has no reserve whatever in commodities or in cash. He owns no capital which may be pawned to provide him with the necessaries of life in an emergency: and, if he did, he would never in all his life earn enough money to redeem the mortgage. Each year begins for him with an empty bin which he has to fill with the grain he raises during the short rainy season: if the harvest fails from any cause, it must continue to remain empty for twelve months more. Therefore, the one night's visit of the elephants to his field means starvation for himself and his family for twelve months. A study of his life during the wet season will show what measures he has to take to avert this calamity. When the rains come the store of the last harvest's grain has begun to run out and he and his family are on short rations and are half starved. With the onset of the rains he becomes a victim of the seasonal epidemic of malaria. The fever-stricken and half-starved man has to work long and strenuous days with no protection from the heavy rain, so that he may not be overtaken by the dry weather before he has planted his crops: and then he has to stay out in the field during the night, under the improvised shelter of jungle leaves, to protect his germinating and growing seedlings from wild animals. He often succeeds in protecting them. But if he yields to the drowsiness which his day's labour and the fever induce and the rain allows him to remain asleep for two hours, the elephant or the pig or the deer may destroy in those two hours the fruit of a season's labour and a year's hope of food. If the Agricultural Instructor advises him to grow a high-yielding six months' paddy in place of his poor three months' variety, he would reply that three months are quite long enough for him to sleep in the field. If he is advised to grow plantains in his chena, he explains that it is impossible to protect them from elephants. He will not grow oranges because monkeys would not allow the fruit to ripen. He will not plant cassava because the deer would not allow it to grow: and if it did grow the pig digs up the tender yam by night and the monkey by day.

Perhaps the narration of an incident which came under our personal notice would complete this dismal picture. A man in the Wanni with completely broken health opened a chena. When the crop was half grown he died. His wife took over the watching of the chena by night. She would stay out in the field with her twelve-year-old son. One night her fever rose and she could not go. The son went out that night with his ten-year-old brother. The next morning the children did not return and the mother staggered into the chena and found the two mangled little corpses. Elephants had devastated the chena beyond repair.

There can be only one answer to the question whether the community is justified in allowing its concern for the wild animal to expose the peasant to this precarious existence. It must be regarded as axiomatic that man and undomesticated beast cannot live side by side. If the country wants a vigorous race of men to inhabit again those areas which are now in forest, the beast must be exterminated from those areas. The sportsman must accept that position. There remain the claims of science to consider. The only method of reconciling these claims with the rights of man appears to be the strict delimitation of the boundaries of the domains of man and of beasts. A sufficiently large reserve may be created in which the beast is supreme, in which it can roam at will, and to which man will be permitted to stray under prescribed conditions and only for scientific observation. Surrounding this there should be a protective belt in which man will not be allowed to live but in which he can move about freely and destroy all agriculturally harmful animals at will. Outside this belt will be man's country in which all animals other than those that are beneficial to agriculture or are quite harmless should be mercilessly destroyed as quickly as possible by the employment of every device of destruction that man can invent. If the use of the flashlight or an invitation to the tourist to come over with his gun can expedite this process of destruction it would be foolish to refuse to employ these measures. Only those who think loosely and try to face both ways at the same time will challenge this conclusion.

SOILS OF THE WET ZONE FORESTS OF THE MATARA, GALLE AND KALUTARA DISTRICTS

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INTRODUCTION

THE study of the soils of the Wet Zone forests has been generally confined to the examination of soil profiles in typical localities of forests under Working Plans investigations. Such examination has been restricted to one or more soil pits in each forest, the site selected being as far as possible typical of the general vegetational conditions in the forest. In these examinations *only* the physical properties of the soils have been studied in the field; the analytical examination of samples has not been attempted. The general methods followed in the examination of profiles incorporate the modern methods of soil study (1).

SITUATION (GENERAL)

The Wet Zone forests form a tract of country lying in the south and west of the Island, corresponding with the region of heaviest rainfall (100–200 inches per annum). Topographically, they are distributed according to the following regions (2):—

Region I.

The coastal plain (first peneplain, 100–300 feet) of the Central Massif. This plain marks the outermost limit of erosion. It is somewhat narrow at the southern end, and widens out at the western portion of the Island. It is for the most part formed from rocks of *archaean* age, and contains some recent alluvial and pleistocene (plateau gravel) deposits.

The topography of the forests within this region is flat, or at most consists of low undulating country. Of the forests examined, the following may be classified under this region:—

Matara District—

Badulukele—extent 453 acres
Masmullekele—extent 2,066 acres
Oliyagankele—extent 1,201 acres
Kekunadura—extent 992 acres

Galle District—

Kottawa—extent 5,652 acres
Yakkatuwa—extent 725 acres

Region II.

An intermediate region between the coastal plain of the Central Massif and the *second peneplain* (1,600–1,900 feet). The altitudinal range of the forests falling within this region is variable; in the Matara and Galle Districts, it is generally restricted to below 750 feet, while in the Kalutara District, the range is considerably more, extending almost to the limits of the second peneplain (1,600 feet).

The topography is characterized by moderately steep slopes leading on to a series of ridges on the more elevated slopes (over 1,000 feet) extending, in general, in a northerly to southerly direction, the western (escarpment) slopes, generally, being more abrupt and steep. The geological formation is *archaean*, recent alluvial or pleistocene deposits being absent.

This region may be sub-divided into the following sub-regions :—

(i.) *Sub-region of swampy and low-lying country* (50–250 feet) containing a single example, Galahitiya (extent 657 acres) in the Kalutara District.

(ii.) *Sub-region of low hills and easy slopes*, general altitudinal range 50–750 feet. This sub-region consists really of the slopes arising from and more closely associated with the coastal plain; the slopes are gradual and may form a series of semi-high plateaux (500–750 feet) at the higher altitudes; in general, the summits rise isolated and rounded from these semi-high plateaux. Of the forests examined, the following may be classified under this sub-region :—

Matara District—

Beraliya—extent 3,983 acres
Dediyagala—extent 9,473 acres
Kanumuldeniya—extent 1,460 acres

Galle District—

Bambarawana and Poddiwala—extent 2,038 acres

Kalutara District—

Yagirale—extent 7,450 acres
Yatagampitiya, Nikgaha and Delmella—extent 5,043 acres

(iii.) *Sub-region of moderately steep slopes*, general altitudinal range 50–1,600 feet. This sub-region consists of the slopes which lead on to and which are more closely associated with the second peneplain of the Central Massif. This region is more or less characteristic of a few large tracts of forest in the Kalutara District. The slopes are, in general, considerably steeper than in sub-region (ii.), extending in a general north to

south direction, in a series of ridges which may ultimately merge into elevated semi-high plateaux, in general over 1,000 feet in altitude, and the summits of which form the limit (1,600 feet) of the altitudinal range. Of the forests examined, the following may be classified under this sub-region :—

Kalutara District—

Topo P. P. 1 (Morapitiya)—extent 14,770 acres
Topo P. P. 2 (Pelenda)—extent 7,600 acres

Region III.

The region of the *second peneplain* (1,600–1,900 feet). This is represented by a single example, Diyadawa (extent 6,383 acres) in the Matara District, forming a flange extending southwards from the Central Massif. This region is marked by very steep slopes forming a continuous range whose upper limits (up to 2,400 feet) form the lower reaches of the intermediate region between the second peneplain and third peneplain (6,000 feet). This region contains the *steepest* slopes, the summits of which form characteristic ranges.

CLIMATIC ZONES

Temperature.—Temperature conditions are, in general, fairly constant over the Wet Zone, the average mean annual temperature being in the neighbourhood of 80°F.

Rainfall.—In general, the average rainfall of the Wet Zone forests shows little variation, being in the neighbourhood of 125 inches. Some correlation is, however, apparent between the distribution of rainfall and topographical features, and according to this, the following zones may be distinguished :—

(i.) *Zone of Minimum Rainfall, 50–75 inches.*—The only forest falling within this zone is Kanumuldeniya in the Matara District ; the low rainfall may be attributed to its proximity to the Dry Zone in the south-east of the Island.

(ii.) *Zone of Intermediate Rainfall, 75–125 inches.*—The forests falling within this zone are restricted to the coastal plain (Region I.) and are confined, therefore, to the forests of the Galle and Matara Districts (with the exception of Yakkatuwa) mentioned under this Region.

(iii.) *Zone of Heavy Rainfall, 125–175 inches.*—All the remaining forests in the Galle and Matara Districts fall within this zone, including also the Yatagampitiya Block in the Kalutara District. This zone is largely associated, therefore, with the sub-region (ii.) of low hills and easy slopes, of Region II.

(iv.) *Zone of Maximum Rainfall, 175–200 inches.*—The forests of the Kalutara District, in general, have the heaviest rainfall,

all approximately in the neighbourhood of 180 inches per annum. This zone is largely associated with the sub-region (iii.) of moderately steep slopes, of Region II.

GEOLOGY (3)

The geological formation underlying the soils is *Charnockite*, a series of gneisses belonging to the *archæan* system, and the mode of formation of the soils is, therefore, chiefly residual. There are, however, isolated instances of evidence of derivation of the soil from pleistocene plateau gravels (4) and recent alluvial deposits, especially in the Region of the coastal plain (Region I.). The *Charnockite* series vary from highly acid hypersthene granites to norites and basic hornblende hypersthenites. The colour of the rock varies from a dark grey in the more acid series, to dark greyish-black in the case of the basic series. The rock displays well marked foliation or banded structure. The series associated with the forest soils appear, for the most part, to be the *acid series.*

SOILS

General Characters

The soils of the Wet Zone being derived, in general, from the same geological formation, and under fairly uniform climatic conditions, show an uniformity in their general physical and chemical properties, belonging to the soil type of Tropical Red Earths (5), verging in some cases on Laterite soils (5).

Physical Properties

In soils derived *in situ*, a gradual change from the parent horizon (C horizon) to the surface (A horizon) is more or less the general rule. Where there is evidence of erosion, a B horizon is sometimes recognizable, this having been derived by illuviation and segregation (6). For a general description of the physical and chemical properties of the Wet Zone Forest Soils, Joachim (7) may be consulted.

CLASSIFICATION OF THE WET ZONE FOREST SOILS

The following is an attempt to classify the soils which have been examined in the Wet Zone in the Matara, Galle, and Kalutara Districts only. This classification is tentative and is correlated with the site conditions reflected in the *dominant height growth** of the tree layer.

**Note.*—In the analysis of site conditions and separation of sites, the four variables (i) climate, (ii) physiography, (iii) soil, (iv) biotic action must be considered. The sum total of these variables is reflected in the *height* growth of trees, and therefore, where variations in the height growth are sufficiently constant and well-marked, the data obtained on the height growth of *dominant* trees may be utilized in separating sites. Dominant height is more reliable than average height in this respect, because it is reasonable to assume that the height growth of *dominant* trees is a direct reflection of the complex of site conditions, and has not been affected by extraneous influences, such as suppression of growth &c., (8).

The descriptions of the soil profiles have been incorporated in the soil profile diagrams appended, which have been adapted from sketches actually made in the field. (Appendix—diagrams 1 to 29).

Seven soil groups are recognized, the distinction being made largely in the distribution, size, and frequency of the gravel and stone constituents in the B and C horizons.

GROUP I.—ALLUVIAL SOILS

These soils are confined topographically to the banks of rivers and streams, the soil, in these instances, being derived from recently eroded detrital material in the form of fine alluvium or sand.

The *soil profile* is characterized by a great depth of homogeneous, loose, coarsely granular sand or sandy loam (A horizon) varying from brown to yellow in colour, with no perceptible humus penetration, sometimes with a mineral skeleton of decomposing boulders, and generally with some accumulation of quartz concretions of small size, below ½ inch in diameter. There is scarcely any further horizon differentiation in the A horizon, the typical features being the well-drained sandy conditions with little or no clay fraction.

In an isolated example, Kanumuldeniya, pit 1, 500 feet, in the Matara District (diagram 1), the soil bears a resemblance to the "cinnamon soils" (9) derived from the pleistocene plateau gravels (4). The soil here is a deep yellow sand to a depth of 40 inches; the A 1 horizon, 0–10 inches, is considerably bleached, being greyish-white in colour. Below 5 feet depth (C 2), the soil is gravelly, but the gradual transition (C 1, 40–60 inches) from this horizon to the homogeneous sand above 40 inches, indicates that its origin is in granitic rock. Further, the altitudes at which these soils occur are not in accord with plateau gravel deposits, which are mostly found in low-lying regions.

In all the other examples, the location of the pit was near the vicinity of a stream. In these cases, the surface horizon (A) occur to a depth of nearly 40 inches; quartz concretions and decomposing rock fragments may be present, indicating the derivation of the soil from transported material. In one example, Banpara, Topo P. P. 2, 300 feet, Kalutara District, (diagram 3), the soil profile is interesting, as it shows the superimposition of the alluvial profile, 0–40 inches, over a more ancient profile (also probably of alluvial derivation). It is probable that successive inundations may cause an overlapping of horizons in such profiles, and the leaching out of material from the surface horizons and re-deposition in a deeper horizon, as indicated by the undulating and merging horizon boundaries.

This group of soils appears to be associated with the best sites, as reflected by the dominant height growth, which is the best in the Wet Zone. The fertility of the soils may be attributed to optimum moisture conditions, good physical texture and good conditions of drainage permitting deep and extensive root penetration.

Vegetation

The vegetation is characterized by the predominance of *Hora* (*Dipterocarpus zeylanicus*), to a frequency of 50 per cent. or more of the tree species, and may therefore be regarded as a *climax** type on these soils. The dominant height growth, shown by *Hora* is in all cases over 100 feet, and extends to as much as 150 feet. The tree-form is straight and the crowns well formed and compact. The associated tree species are variable ; the common associated species are *Diyapara* (*Wormia triquetra*), *Godapara* (*Dillenia retusa*), *Milla* (*Vitex pinnata*), *Hedawaka* (*Chaetocarpus castanocarpus*), *Etamba* (*Mangifera zeylanica*), *Aridda* (*Camnospermum zeylanicum*), *Peleng* (*Kurrumia zeylanica*), *Malaboda* (*Myristica dactyloides*) and *Badulla* (*Semecarpus gardneri*).

Examples :—

Matara District—

Kanumuldeniya—pit 1, S.E. end, 500 feet (diagram 1)

Kalutara District—

Yatagampitiya Block—Nikgaha, 100-200 feet (diagram 2)
Topo P. P. 2—1. Banpara, 300 feet (diagram 3)
2. Walakada (Pelenda), 300 feet (diagram 4)

GROUP II.—NON-GRAVELLY LOAMS (RESIDUAL)

These soils are widely distributed and appear to be derived *in situ*. They are also characterized by association with a *Hora* climax type, and in this respect resemble the alluvial soils of Group I. Their suitability for *Hora* may be attributed to the absence of an accumulation of ironstone concretions in a more or less impenetrable zonal layer (B horizon), and to the relatively good moisture conditions, consequent, probably, on a high water table and good drainage.

The *soil profile* is characterized by a shallow A 1 horizon to a few inches, of loose, porous loam, usually sandy, with some

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**Note*.—The term *Climax* is used here, and throughout this paper, in the sense accepted by the supporters of the Polyclimax Theory of Succession (10). A climax type of vegetation is recognized as one which is in equilibrium with the site conditions, that is, which would show a mature type of soil profile, stable topographic features, and characterized by the presence of *climax dominants*. The majority of such climaxes are, therefore, *edaphic climaxes* (11), into which the *Hora* climax type herein recognized falls.

In the terminology of Clements (12), that is, in the acceptance of the Monoclimax theory, the *Hora* climax would correspond to a *Post-Climax* (12), occurring in the moister localities, and distinguished by certain characteristic edaphic features.

humus penetration. The rest of the profile shows a gradual change from a rich brown or reddish-brown deep loam or clayey loam (A 2) usually 30 to 36 inches in depth, to the C horizon of parent rock in process of decomposition, consisting of friable rock brash or decomposing rock, interspersed with numerous veins or pockets of clay intermingled with coarse quartz sand.

Hard iron-oxide concretions are *absent* in the A horizon, being replaced by soft mottlings of red iron oxides, which give the uniform reddish tint to the C horizon. In some instances, for example, Oliyagankele, Matara District, 250 feet (diagram 6) and Denihena, Topo P. P. 1, Kalutara District, 600 to 700 feet (diagram 8), an incipient B horizon of accumulated ironstone nodular concretions, usually large, may be present. Drainage is good, and root penetration deep and spreading.

Vegetation

As mentioned above, these soils together with those of Group I. may be considered *Hora climax* soils, as in all the examples (excepting Banpara, Topo P. P. 2, 300 feet, diagram 3) *Hora* is dominant. The dominant height growth within this group varies from 100 to 140 feet. As on the soils of Group I., *Hora* forms about 50 per cent. of the total tree species. The chief associated species are the same as those occurring on the soils ot Group I.

Examples :—

Matara District—

Oliyagankele, southern end, 250 feet (diagram 6)

Galle District—

Kottawa (Arboretum) 250–300 feet (diagram 5)

Kalutara District—

Topo P. P. 1 (i.) Digane, 700–800 feet (diagram 7)
(ii.) Denihena, 600–700 feet (diagram 8)

GROUP III.—HOMOGENEOUS GRAVELLY LOAMS (RESIDUAL)

In this group, most of the soils have been derived from *archaean* rock ; there is evidence, however, in an isolated instance, of possible derivation from pleistocene plateau gravels (4).

These soils, like the soils of Group II., appear to have been formed *in situ* by the gradual weathering of the parent granite, leaving a skeleton of ironstone nodular concretions or partly decomposed residual rock, which is fairly well distributed, but not forming a compact layer interfering with the permeability of the soil. This group is, therefore, similar to the soils of Group II., except for the inclusion of the gravelly or stony skeleton. On the better drained soils of this group a *Hora climax,* similar in all respects to that obtaining in Group II., may be found.

The *soil profile* shows a gradual change from the surface to the parent material. As in the Group II. soils, the A 1 horizon is shallow and is composed of loose, dark-brown loam with some little humus penetration. This is followed by a deep loam or clayey loam, 36 to 48 inches in depth, varying from yellowish-brown to dark-brown in colour ; in some cases the clay fraction is high, especially in the C 1 horizon, where it may occur as bands or pockets mixed with coarse quartz sand. The gravel or stone inclusions are usually fairly prolific, but are usually absent from the A 1 horizon, being more or less homogeneously distributed in the other horizons (A 2 &c. to C 1). In the more fertile soils, reflected in the better height growth, these concretions may be more friable. Drainage is good, and root penetration deep and spreading. In some instances, for example, Masmullekele, pit 2, 200 feet, in the Matara District (diagram 10), an incipient B horizon of accumulated ironstone concretions may be present.

Vegetation

The vegetation on these soils is high forest, with a dominant height varying from 90 to 150 feet. The best height growth is usually found on soils associated with *Hora, e.g.*, Beraliya, Matara District, 600 feet, (diagram 11), where the dominant height growth is 135 feet. The *Hora* climax is found on two examples on the soils of this group, *viz.*, Beraliya (mentioned above) and Masmullekele, pit 2, 200 feet, in the Matara District (diagram 10). In the other examples, in one instance *Na* (*Mesua ferrea*) was the predominant species with a dominant height growth of 90 to 100 feet (Masmullekele, pit 1, 350 feet, diagram 9) and in the other *Kirihembiliya* (*Palaquium petiolare*) growing to a dominant height of 150 feet (Dediyagala, pit 2, 200–300 feet, Matara District, diagram 12).

Examples :—

Matara District—

Masmullekele : pit 1 (Jayasamankanda), 350 feet (diagram 9)
pit 2 (near Batuwita-oya) 200 feet (diagram 10)

Beraliya, (Kekirihena), 200 feet (diagram 11)

Dediyagala, pit 2 (Dediyagala) 200–300 feet (diagram 12)

Galle District (near Elpitiya)—

Yakkatuwa plantation, 100 feet (diagram 13)

In the last example in Yakkatuwa plantation (Jak and Mahogany) the soil appears to be probably of pleistocene origin (plateau gravel) according to Joachim (7) (pages 149, 150), the top layer of sand being removed by erosion. In this soil, the gravel and stone inclusions form more or less a compact mass, so that root penetration is concentrated mostly in the surface, and is very poor to depth. The soil is a brown loam becoming clayey at a depth of 44 inches.

An alternative possible explanation for the compact gravel mass, is that an undulating water table has caused precipitation in a B horizon proper; there is evidence that this may be so, because below 44 inches, the soil is a clayey loam with partly decomposed rock inclusions (derived probably *in situ*) but with the absence of gravel (ironstone nodular concretions). This horizon does not appear to have been observed by Joachim.

In the adjoining forest, the dominant height growth does not exceed 65 feet, the forest, in general, being poor. *Pepiliya* (*Aporosa latifolia*), *Del* (*Artocarpus nobilis*), *Hedawaka* (*Chaetocarpus castanocarpus*), *Netaw* (*Xylopia parviflora*) and *Angana* (*Nelitris jambosella*) are the chief species.

GROUP IV.—SOILS WITH A ZONAL GRAVEL LAYER

These soils differ from the soils of Group III. in that the gravel distribution is not uniform, but is partly concentrated into a gravel zone (B horizon proper) near the surface, of varying thickness, usually less than a foot thick. This layer would bear a similarity in its origin to the iron-oxide " pan " found in some *podsol* soils in the Temperate Zone; the gravel layer, however, does not become consolidated to form a more or less homogeneous hard pan.

In almost all instances this zonal gravel layer has probably originated by illuviation and segregation, becoming concentrated in the surface soil by erosion (6). Further evidence of this is present in that the gravel mass is sometimes embedded in a matrix which is more clayey than the soil immediately above and below. In some cases this layer may have been formed by the effect of an undulating water table causing the precipitation of oxides of iron and alumina from a solution of these in the A horizon. This condition may have obtained in the case of Kekunadura forest in the Matara District (diagram 16). Another possible example has been included under soils of Group III. (Yakkatuwa, diagram 13).

The *soil profile* shows clearer and more horizon differentiation than the soils of Group III., especially as the B horizon is fairly distinct. The A horizon (usually one layer) is shallow in the more infertile soils as evidenced in Kanumuldeniya, pit 2, 3 inches (diagram 17), Kekunadura, 6 inches (diagram 16), Morapitiya, Topo P.P. 1, 9 inches (diagram 18). It may extend up to 16 inches in the more fertile soils as evidenced in Diyadawa (diagram 19), Badullukele (diagrams 14 and 15) and Kottawa Reserve (diagram 20). This horizon varies from a loam to a clayey loam, brown to reddish-brown in colour. It is characterized by the relative infrequency of gravel or stone content. Root penetration is good in this horizon.

The B horizon occurring below this varies from 3 to 9 inches in thickness and consists of a more or less well defined reddish-brown layer of fairly compact gravel of varying sizes, usually small, (average ½ to ¼ inch in diameter) sometimes associated with similar concretions of quartz, embedded in a loamy or clayey matrix. Root penetration is usually poor below this horizon.

The C 1 horizon consists mainly of secondary parent material decomposed *in situ* ; it is usually a reddish-brown or yellowish-brown loam or clayey loam with red mottlings of ironoxides and occasional gravel or quartz concretions, to a depth of 36 to 48 inches, followed by a C 2 horizon of decomposing rock with pockets of clay mixed with sand (of the usual type). Root penetration is poor in the C horizons. In isolated instances, *e.g.*, Diyadawa, pit 1, 1,600 feet, in the Matara District (diagram 19), the typical C 1 horizon may be absent, the disintegrated rock then occurring immediately below the B horizon.

Vegetation

The vegetation of the soils of this group is in all cases high forest, sometimes in a late stage of secondary succession (Kottawa Reserve, Galle District), in some cases amounting to low jungle (Kekunadura Reserve, Matara District). The dominant height growth varies from 70 to 100 feet. *Hora* is predominant in only one example (Badullukele, pit 2, 250 feet, Matara District) ; but in this case the predominance was due to intensive management favouring *Hora*. It is also in this example that the maximum height growth was observed. In all the other cases the forests is of a very mixed type ; *Milla* (*Vitex pinnata*), *Ipetha* (*Cyathocalyx zeylanicus*), *Diyapara* (*Wormia triquetra*), *Gulumora* (*Cryptocarya wightiana*), *Badulla* (*Semecarpus gardneri*), *Hedawaka* (*Chaetocarpus castanocarpus*) are species frequently associated with these soils. The shrub layer is usually well represented on the soils.

Examples :—

Forest	Altitude in feet	Depth and Thickness of B horizon
Matara District.		
Badullukele, pit 1, S.E. end (high forest)	250 ..	12–18 inches (diagram 14)
Badullukele, pit 2, same locality, (*Hora* under management) ..	250 ..	12–18 inches (diagram 15)
Kekunadura (Western end) ..	200 ..	6–12 inches (diagram 16)
Kanumuldeniya, pit 2 (S.W. end) ..	600 ..	3–9 inches (diagram 17)
Diyadawa (Diyadawakanda) ..	1,600 ..	16–19 inches (diagram 19)
Galle District.		
Kottawa Reserve (near Circuit Bungalow)	150 ..	16–25 inches (diagram 20)
Kalutara District.		
Morapitiya, Topo P. P. 1 ..	100–200..	9–15 inches (diagram 18)

GROUP V.—SWAMP SOILS (CLAYEY SOILS)

This group consists of soils definitely associated with swampy or water-logged conditions and bad drainage. They usually occur in low-lying or plateau sites, near *deniyas*, the water table being relatively high. These soils are, therefore, restricted in distribution, only two examples being found, of which one (Galahetiya, Kalutara District) is typical, as the forest is periodically inundated. The conditions of poor drainage are correlated with the formation of *clay* below the surface (A 1) horizon which may contain gravelly or stony inclusions; this horizon (A 2) may thus resemble the B horizon (zonal gravel layer) of the soils of Group IV., and have originated similarly.

In the typical *soil profile* the A 1 horizon is a deep (up to 11 inches), dark-brown to blackish loam, with relatively high (for tropical soils) proportion of humus accumulation. It is usually devoid of a mineral skeleton. Root penetration and drainage are good in this horizon. The A 2 (or probable B) horizon below this (up to 26 inches) consists of light or dark-brown clay with well-distributed gravel as in Galahetiya, Kalutara District, 50-100 feet (diagram 27) or large stony inclusions as in Morapitiya, Topo P. P. 2, Kalutara District, 450 feet (diagram 28). The parent horizon, C 1, may be either a stiff clay with iron-oxide red mottlings (Galahetiya), or decomposing rock with the usual veins of clay and coarse quartz sand (Morapitiya). Root penetration usually ceases at the A 2 horizon. The soils are relatively infertile, the dominant height growth being restricted to below 70 feet.

Vegetation

The vegetation usually consists of mixed forest, of somewhat restricted growth. *Hora* is found in Morapitiya as a frequent species, although its height growth was restricted. The site selected was, however, on the ecotone of the *Hora* type and general mixed type of forest, and the soil, therefore, cannot be taken as representative of the *Hora* climax soils. The surrounding type was forest in a secondary stage of succession with *Milla* (*Vitex pinnata*), *Alubo* (*Syzygium makul*), *Peleng* (*Kurrumia zeylanica*), *Hedawaka* (*Chaetocarpus castanocarpus*) and *Diyapara* (*Wormia triquetra*) as frequent species. In the other example (Galahetiya), *Uruhonda* (*Lasianthera apicalis*), *Hedawaka* (*Chaetocarpus castanocarpus*), *Welipenna* (*Anisophyllea cinnamomoides*) and *Kokatiya* (*Garcinia terpnophylla*) were the predominant species in secondary forests.

Examples :—

Kalutara District.

Galahetiya (central portion), 50–100 feet (diagram 27)
Morapitiya, Topo P. P. 2, 450 feet (diagram 28)

GROUP VI.—SHALLOW TRUNCATED AND BOULDER SOILS

This group does not, as in the soils of Group I.–V., present well-defined uniform characteristics; from their derivation the soils belonging to this group bear a general resemblance to the soils of Group IV., but have, as a result of more *severe erosion*, assumed a general *shallow* or *truncated* appearance, the surface (A) horizon being shallow and the parent (C) horizon occurring at little depth. These soils are also more or less associated with outcrops of hard laterite and exposed boulders of varying size, often culminating in large outcrops of slab-rock. The eroded nature of these soils is bound up very much with intensive "chenacing" or other form of exploitation; this is brought out vividly by the present vegetational type which is in almost all examples forest in an early sub-sere (secondary successional phase) with dominant heights not exceeding 70 feet.

In general, the *soil profile* shows a shallow A 1 horizon, seldom exceeding one foot in depth; this is usually a dark-brown loam with some humus penetration and often contains either nodular ironstone concretions or surface boulders in various stages of decomposition, which ultimately form nodular concretions.

Below this, a secondary parent horizon outcrops to a depth varying from 26 to 48 inches, usually a reddish-brown to yellowish-brown loam (or clay sometimes disposed in pockets between decomposing boulders) and containing nodular concretions of ironstone and, sometimes, quartz of varying size. Large boulders over 3 feet in diameter are often present in the very bouldery soils. This horizon merges into a C 2 horizon of parent rock in various stages of decomposition, from a compact, yellow clay with red iron-oxide mottlings, as in Suwandakanda, Kalugalmukalana, 400–500 feet in the Kalutara District (diagram 22) to decomposing rock with veins of clay (alumina) with mottlings of red oxides of iron. Root penetration is naturally poor in the C 1 and C 2 horizons; the soils appear to be relatively infertile.

Vegetation

The vegetation is marked by its poor character, and is generally forest of a secondary successional type. This may be divided into :—

(*a*) *Scrub jungle*, characterized by typical *Weraniya* (*Hedyotis fructicosa*)—*Bowitiya* (*Melastoma malabathricum*) associes, *e.g.*, Yagirale, 200 feet, Kalutara District. A later stage of this type is characterized by predominant *Bata* (*Ochlanda stridula*) and a few sporadic trees, *e.g.*, Botalawa, Kalugalmukalana, 900–1,000 feet, Kalutara District.

(*b*) *Low jungle* composed of shrubs and trees below 30 feet in height. *Kekiriwara* (*Schumacheria castaneaefolia*) and *Peratambala* (*Gaertnera vaginans*) are characteristic shrub species. The tree species are chiefly *Pepiliya* (*Aporosa latifolia*), *Godapara* (*Dillenia retusa*) and *Diyapara* (*Wormia triquetra*), *e.g.*, Bambarawana, 200 feet, in the Galle District.

(*c*) *High forest.*—This is a poor type, trees being sparse and tree form stunted with characteristic stag-headed crowns. Dominant heights do not exceed 70 feet, and are, in general, much below this. Characteristic tree species are *Milla* (*Vitex pinnata*), *Diyapara* (*Wormia triquetra*), *Hedawaka* (*Chaetocarpus castanocarpus*), with less frequent *Aridda* (*Camnosperma zeylanica*), *Alubo* (*Syzygium makul*), *Welipenna* (*Anisophyllea cinnamomoides* and *Ipetha* (*Cyathocalyx zeylanicus*). *Kekiriwara* (*Schumacheria castaneaefolia*) and *Bata* (*Ochlanda stridula*) are frequent species in the shrub layer.

Examples :—

Matara District—

Dediyagala, pit 1 (Hulanduwa), 100–200 feet (diagram 24)

Galle District—

Bambarawana (Western boundary) 200 feet (diagram 25)

Kalutara District—

Kalugalmukalana : Botalawa, 900–1,000 feet (diagram 23)
Yakupitiya, 300 feet (diagram 21)
Suwandakanda, 400–500 feet (diagram 22)
Yagirale (near Udugama), 200 feet (diagram 26)

GROUP VII.—KEKILLA SOIL

A complete description of these soils is given by Joachim (13) under the Fernland Soils.

These soils form a well-defined group associated specifically with the occurrence of almost a pure consociation of the fern *Kekilla* (*Gleichenia linearis*).

These soils are widely distributed in the Wet Zone, especially in the Kalutara District. *Kekilla* is associated frequently with low jungle occurring therein in intervening tongues and patches (sometimes associated with the occurrence of Illuk grass—*Imperata arundinacea*).

The soil is of a very poor type with a varying accumulation of a well-defined black, acidic humic layer. In the moister areas (in the near vicinity of high forest) where *Kekilla* is less frequently destroyed by burning, this layer is thick. In the

more exposed areas it is thin, and the soils dry, compact and gravelly, as a result of the frequent burns and accompanying erosion.

In the typical *soil profile* examined in Yatagampitiya, 100-200 feet, in the Kalutara District (diagram 29), the A 1 horizon consists of a blackish, sandy loam with a high humus accumulation (mostly derived from *Kekilla* roots) varying from a depth of ½ to 8 inches. Below this an A 2 horizon may sometimes be recognized, about 7 inches in thickness; this horizon is also blackish in colour with abundant quartz and ironstone concretions; this layer is comparable with the zonal gravel layer (B horizon) of the soils of Group IV. The parent horizon below this consists of brown or yellowish-brown compact clay with, usually, quartz and ironstone concretions and inclusions of sandy quartz pockets.

According to Joachim (13) these soils are very acid (pH 4·8 to 5·1); this high acidity may be attributed to the reaction of the acid *Kekilla* humus on the soil.

Vegetation

Shrubs, typically *Weraniya* (*Hedyotis fructicosa*), *Bowitiya* (*Melastoma malabathricum*) and *Wana-idala* (*Wenlandia notoniana*) are frequently found associated with the characteristic *Kekilla*. Sporadically, small stunted trees such as *Diyapara* (*Wormia triquetra*), *Godapara*, (*Dillenia retusa*), *Pepiliya* (*Aporosa latifolia*) and *Kina* (*Calophyllum tomentosum*) may occur. Germination of seedlings appears to be difficult, as a result of the thick humus layer and frequent burns. The *Kekilla* vegetational type appears to be a relatively stable one, probably a *fire climax* (disclimax (12) of Clements), initiated by "chenaeing", and perpetuated by periodical fires.

Examples :—

Kalutara District—

Yatagampitiya Block: Yatagampitiya (2 pits) 100–200 feet (diagram 29)

CONCLUSION AND SUMMARY

The study of the profile characteristics of the Wet Zone forest soils indicate that a relationship between purely physical characters of the soils and the site conditions, as reflected in the dominant tree height growth, may be established; on this basis, a classification of the Wet Zone forest soils into seven groups has been possible. This classification confirms the tentative conclusion arrived at by Joachim (7) in his studies on some forest soils of the wet low-country that "the degree and rate of growth appear to be conditioned by the consistency

and disposition of the gravel constituents in the B and C horizons"; "the actual analytical composition of the soils (examined) does not vary very appreciably".

It has been possible, also, to relate the well-defined characteristics of the soils of Groups I., II. and III. with the distribution and predominance of a tree species, namely, *Hora* (*Dipterocarpus zeylanicus*) which is recognized as a climax dominant on these soils. The soil Groups IV., V. and VI. are associated with a mixed type of forest in which certain sub-seres may be recognized, characterized by certain shrub and tree communities. The soil Group VII. is associated specifically with the occurrence of *Kekilla* (*Gleichenia linearis*) in an almost pure consociation, which may be recognized as a fire climax.

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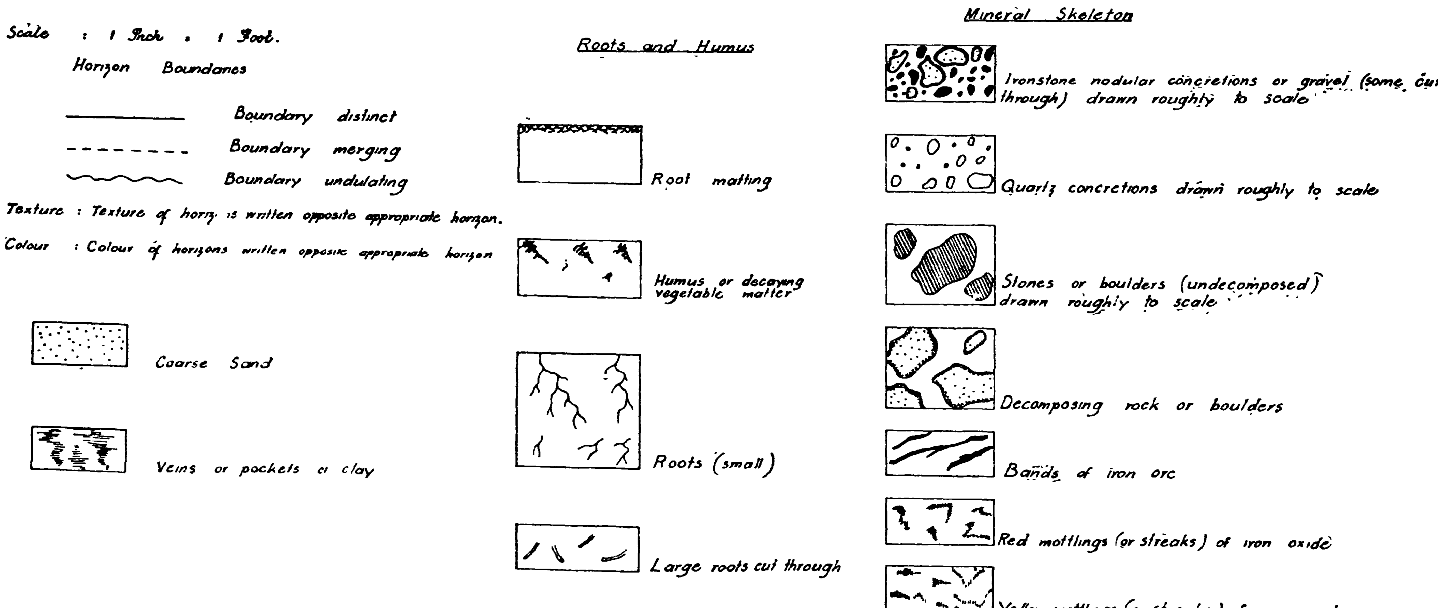
APPENDIX

Soils of the Wet Zone Forests of the MATARA GALLE & KALUTARA DISTRICTS

PROFILE DIAGRAMS

LEGEND



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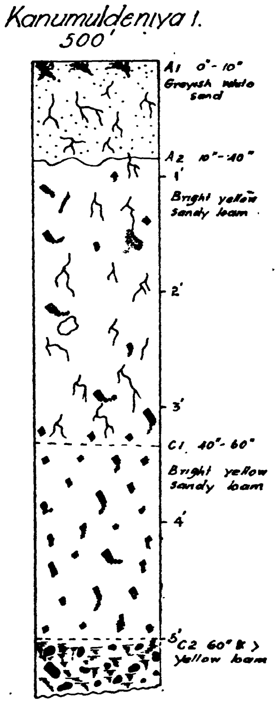
GROUP 1



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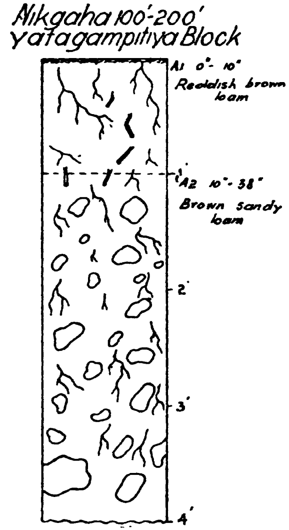

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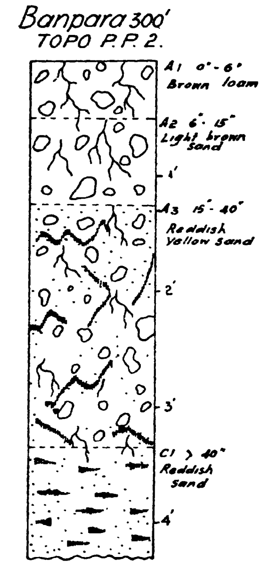

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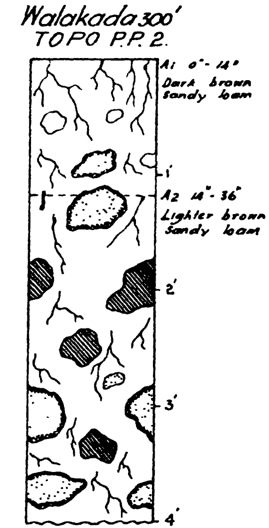

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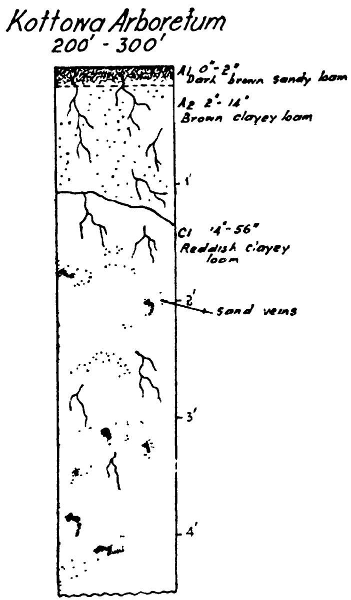
Block by Survey Dept. Ceylon.

—GROUP II—



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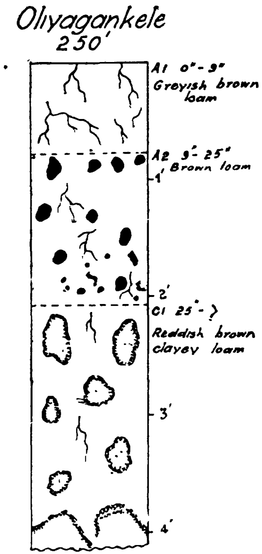

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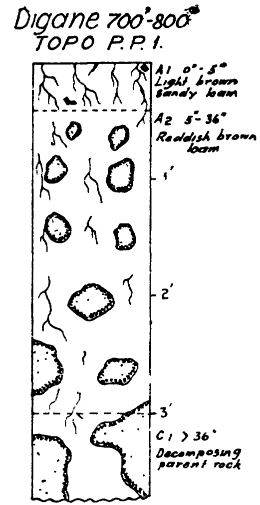

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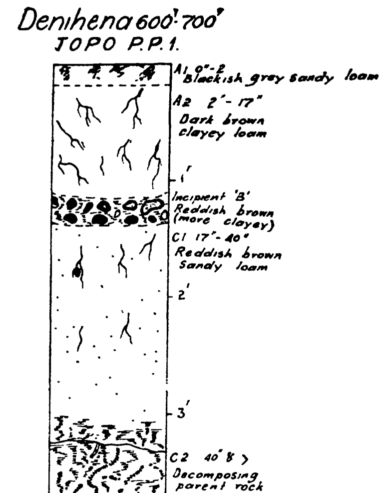

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Block by Survey Dept Ceylon.

GROUP III

Masmullakele 1.
350'

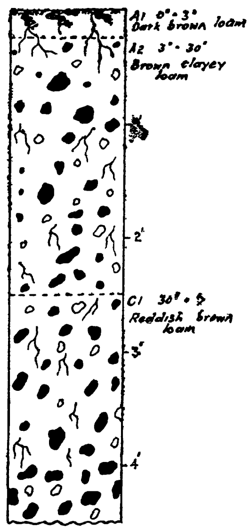


DIAGRAM 9.

Masmullakele 2.
200'

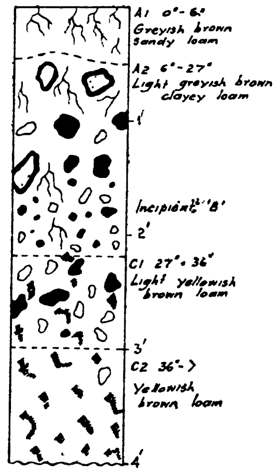


DIAGRAM 10.

Beraliya
600'

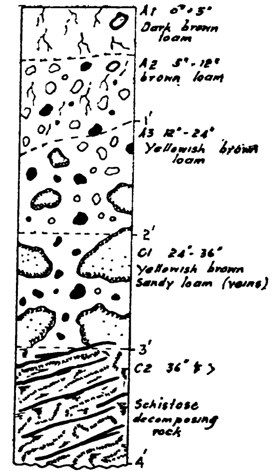


DIAGRAM 11.

Dediyagala 2.
200'-300'

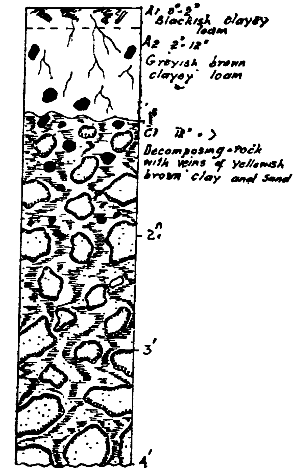


DIAGRAM 12

Yakkatuwa
100'

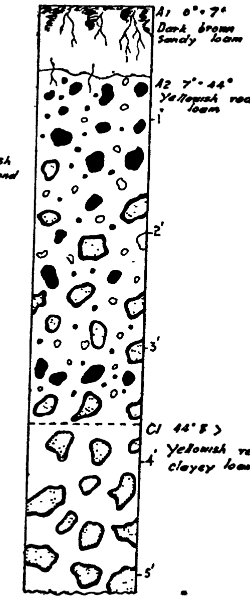
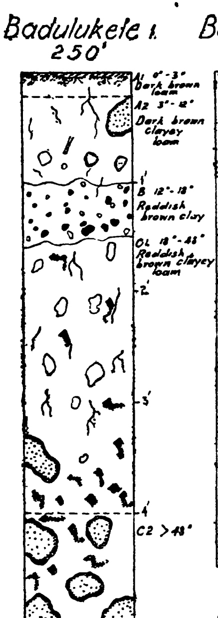


DIAGRAM 13.

Block by Survey Dept. Ceylon.

— GROUP IV —



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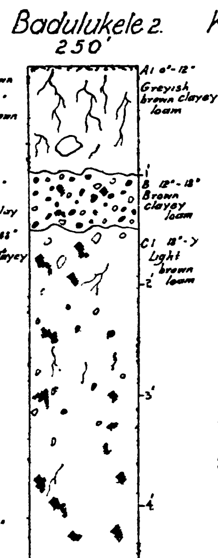

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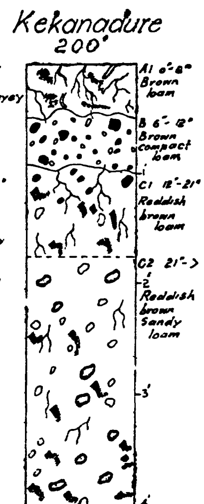

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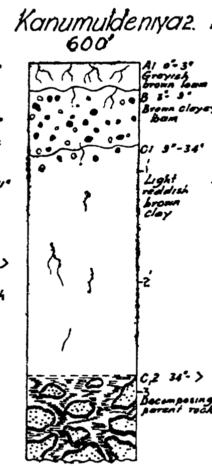

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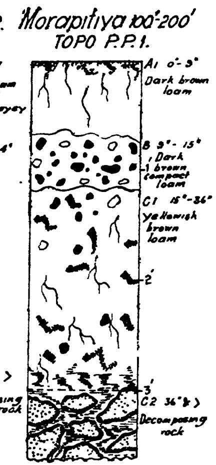
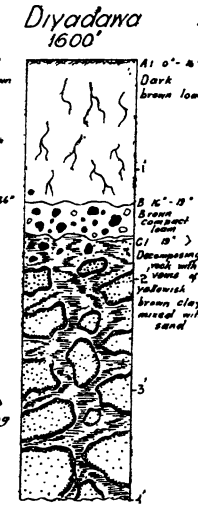


DIAGRAM 18.



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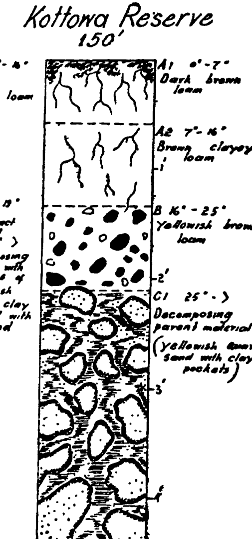

DIAGRAM 20.

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— GROUP V —

Galahitiya (Molkawa)
50' - 100'

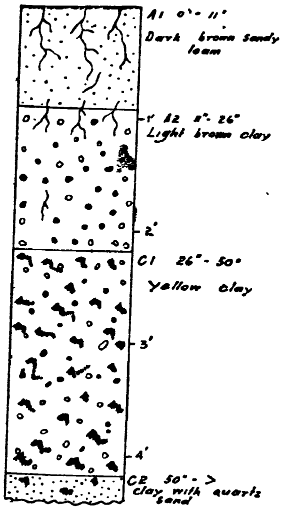

DIAGRAM 27.

Morapitiya 450'
TOPO P.P.2.

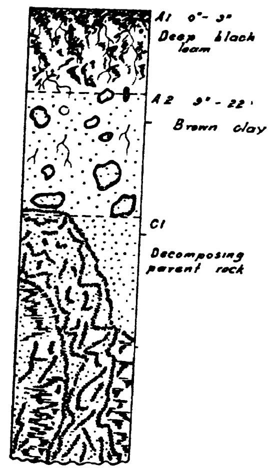

DIAGRAM 28.

— GROUP VII —

Yatogampitiya Block
100'- 200'

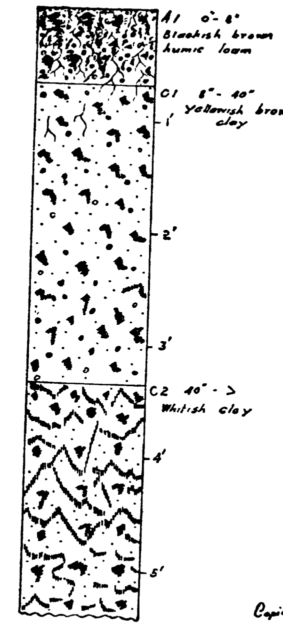

DIAGRAM 29.

Copied by
S. M. D. Raphael
R.A 20-3-39.

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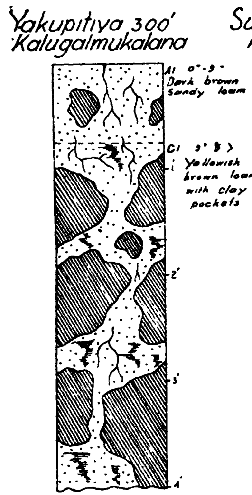
— GROUP VI —



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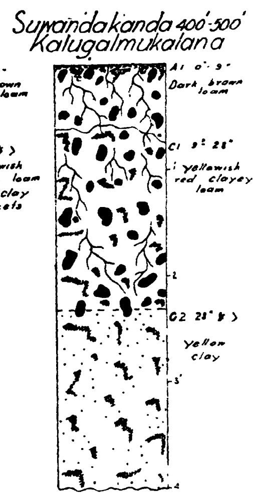

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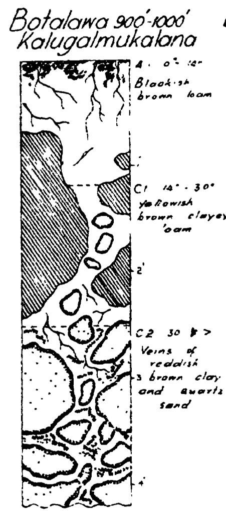

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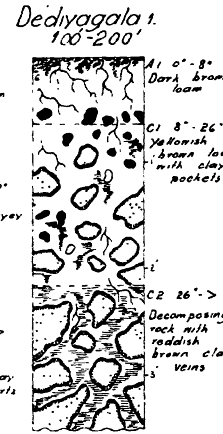

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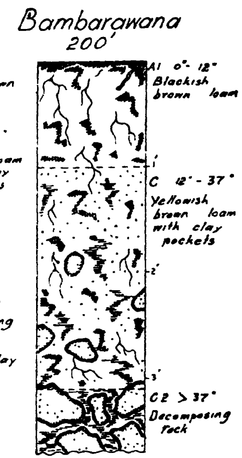

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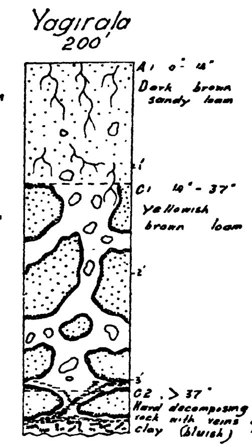

DIAGRAM 26.

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A MULTIPLE SEEDED VARIETY OF RICE (ORYZA SATIVA L.)

G. V. WICKRAMASEKERA, Dip. Agric. (Poona), A.I.C.T.A. (Trinidad),
ACTING PADDY OFFICER

AS far as the writer is aware, no authentic case of polyembryony in rice has yet been recorded. Kuwada (1) in his cytological studies of *Oryza sativa* L. records an " abnormal formation of two embryo sac mother cells". It is claimed that this suggests the possibility of polyembryony in rice. Komura (2) records a rice grain which, upon germination, produced two plumules which reached maturity. Rodrigo (3) records a rice grain of the variety *Initiw* which, on germination, produced two plumules each with a primary radicle. The seed was normal-sized, and when about a fourth of the hull of the seedling was removed, it was observed that each of the plumules had a separate radicle. The claim that the germinated seed is a case of polyembryony in rice is based on " the presence of two distinct primary radicles ". About 107,000 grains of each of *Initiw* and *Tiniaong* were germinated. One seed of the latter produced two plumules while none of the former produced more than one plumule. Jenkin W. Jones (4) records a case in which a seed of a cross between the rice varieties *Yosemite* × *Nimai Kawa Mochi* made at Shafter, California, in 1926, produced two hybrid seedlings which on examination were found to come from one grain. One seedling produced 15 and the other 16 panicles. The caryopsis was not dissected in any of the recorded cases of polyembryony to ascertain whether more than one seed were enclosed within the glumes.

At Peradeniya in trials made in pot cultures to ascertain the maximum degree of salinity which some varieties are reputed to tolerate at different stages of their growth, T.E.B. 1, a variety from Travancore, was observed to produce a seedling with two plumules and two primary radicles, *i.e.*, one for each plumule. On dissection it was found that two separate seeds were enclosed within the glumes of a single caryopsis. When a few grains of this variety were examined, it was observed that several had two to three separate seeds enclosed within the glumes of a single caryopsis. Several of the fresh seeds on germination produced two or three plumules with a corresponding number of primary radicles. (Plate I., Fig. A A' & B B'.)

Eight days after these seeds germinated, the glumes were removed and the seedlings separated out and grown in pots until they reached maturity. The spikelets of these inflorescences contained from 1 to 3 pairs of stigma and a corresponding number of ovaries (Plate I., Fig. C.). Each caryopsis of the matured grains contained 1–3 seeds. Some of the grains were partially formed.

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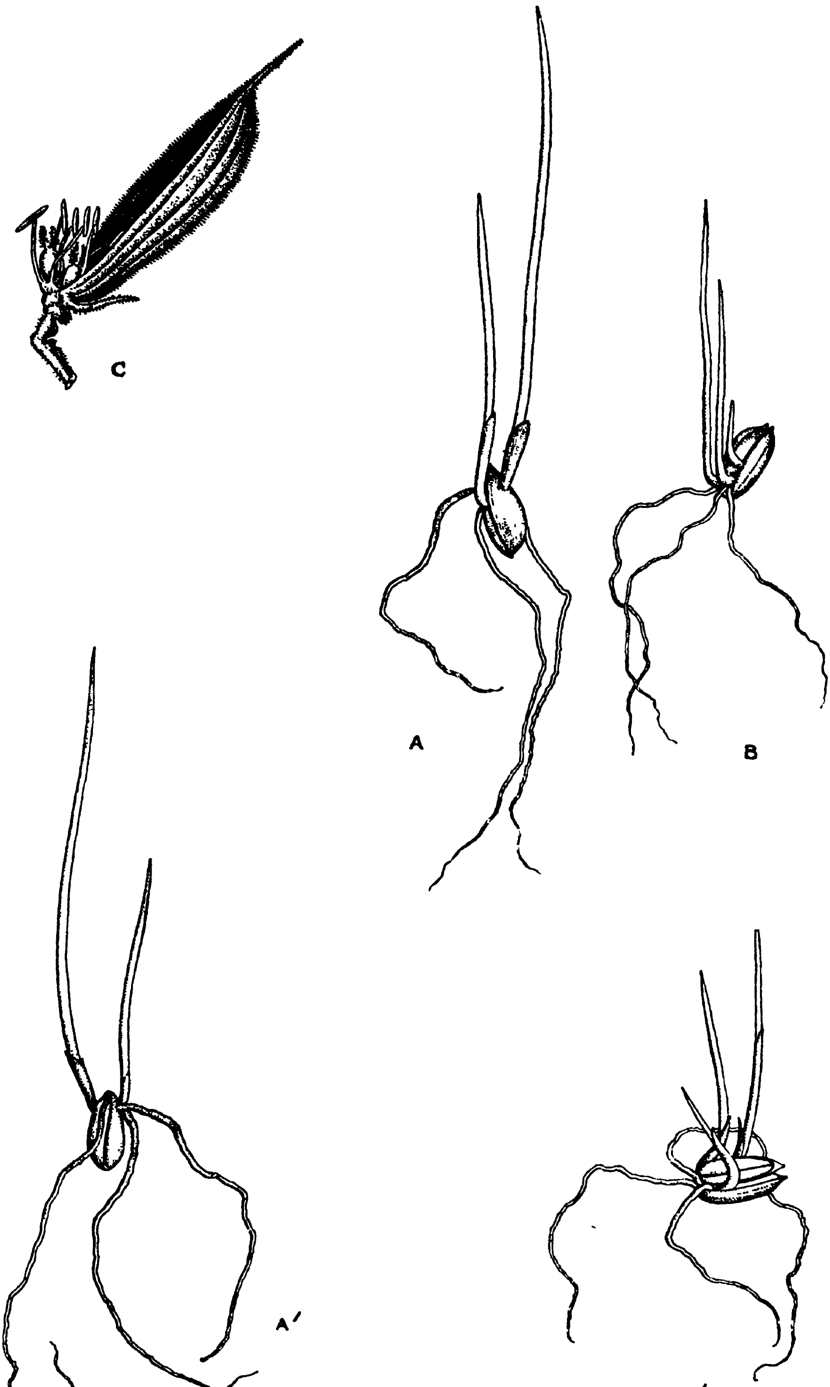

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PLATE I.

SOME SUGGESTIONS FOR THE CONTROL OF THE CITRUS AND MANGO FRUIT-FLY (DACUS FERRUGINEUS)

J. C. HUTSON, B.A., Ph.D.,
ENTOMOLOGIST

THE females of the citrus and mango fruit-fly usually start laying eggs in fruits, such as oranges, grape-fruit, mangoes, &c., just before these begin to ripen. The eggs are laid inside the fruit and hatch within one week into maggots which tunnel about inside the fruit, causing it to decay and sometimes to drop early. The maggots are full-grown in 1 to 2 weeks and come out of the fruit, drop to the ground and form their puparia or cocoons about 2 inches below the surface. Maggots emerging from fallen fruit usually pupate in the soil under or near the fruit. The pupal stage lasts about 1 to 2 weeks, after which the male and female flies come out of the soil in approximately equal numbers. The female flies may remain for at least one month after emergence before laying their eggs, and since they require food before mating and egg-laying, they can frequently be attracted to feed on a sweetened poisoned bait and be killed before they can lay their eggs.

This pest is usually present in considerable numbers in any citrus or mango plantation during the fruiting seasons, but the flies themselves frequently pass unnoticed, and the presence of the pest is not usually detected until much damage has been done and the fruit has begun to fall prematurely or turn rotten on the trees as the result of maggot infestation. By that time it is usually too late to start a control campaign with any real prospect of success and nothing can be done beyond the regular collection and destruction of fallen fruit.

These notes are intended to show that this fruit-fly can be satisfactorily controlled and that most of the crop in a garden or orchard can be saved if the suggested control campaign is started in good time and carried out thoroughly and systematically. It will be noted that (1) citronella oil is a very useful indicator of the seasonal prevalence of this fruit-fly ; (2) that a sweetened poisoned bait can be used to the best advantage during the seasons of prevalence ; (3) that bagging of half

to two-thirds grown fruits serves to protect them from subsequent attacks of fruit-flies to a great extent, but does nothing towards reducing the numbers of these flies; and (4) that the systematic collection and suitable disposal of all fallen fruits are essential to the success of any other control measures employed.

1. CITRONELLA OIL LURE

(for *males* of the citrus and mango fruit-fly)

Experiments have shown that the ordinary commercial citronella oil is quite attractive to *male* flies of the citrus and mango fruit-fly (*Dacus ferrugineus*) when exposed in glass jam-jars two-thirds full of water with about 10 drops of the oil on the water. The jar can be hung on the branch of a tree by an arrangement of wires and the jar-cover or a cigarette tin cover should be suspended about two inches above the jar to keep out heavy rains. The water and oil should be renewed twice a week during dry weather and once a week during wet weather and the catch of flies counted. The *males* of the citrus fruit-fly are small, dark-brown insects, a little larger than house flies, with black and yellow bands and stripes on the body and a pair of clear wings. Occasionally a few other flies and other smaller or larger insects may be attracted to the citronella jars, but the fruit-flies can soon be distinguished. The type of tin recommended for poisoned bait can also be used for the citronella oil lure without the cloths, but may not be quite so effective as the glass jars.

Since citronella oil does not attract the egg-laying *female* flies, it has no special value as a control measure for this pest. This oil when exposed in jars of water does, however, serve as an indicator that the pest is present in an orchard or garden, since it is known that both *male* and *female* flies of this species may be present at about the same times of the year and in approximately equal numbers.

It may be mentioned that the vanilla essence, ammonia and water lure recommended in Australia has not proved attractive to our fruit-flies.

In order to find out whether the citrus fruit-fly is present in a fruit area it is necessary to expose two or three citronella lure jars on trees as soon as the earlier fruits are about half-grown. When the number of *male* fruit-flies per jar rises to about a dozen or more in two or three successive weeks, then it is usually advisable to start using the poisoned bait according to the instructions given.

There may be two periods during the year when fruit-flies are unusually numerous, that is, a major and a minor season of prevalence, and these usually occur when citrus or mango trees

or both are in fruit. These two periods of prevalence may vary somewhat according to the district, and fruit growers can obtain this information for their own districts by the use of the citronella lure jars during the early part of the fruiting seasons. For instance, at Peradeniya there is a minor season of fruit-fly prevalence during February and March, coinciding more or less with the secondary fruiting season of citrus and with the mango fruiting season. This is followed by a decline in numbers of flies during April and May. Then there is another marked rise in numbers to the major season of prevalence from June to August coinciding approximately with the main fruiting season of citrus.

2. POISONED BAIT

(for both sexes of the fruit fly)

Poisoned bait can be used to the best advantage during the periods when fruit-flies are likely to be most numerous, that is, mainly during the fruiting seasons of citrus and mango. If citronella jars have not been used, then baiting should be started about six weeks before the earlier fruits are expected to ripen and carried on throughout the season. It is generally unnecessary to use it at other times of the year.

The following is the formula for making the bait : —

Either sodium silicofluoride powder *or* lead arsenate powder	2	oz.
Cheap sugar	2	lb.
Water	4	gallons.

The same proportions can be used for larger or smaller quantities. Mix the powder with a little water and stir this into the sweetened water made by dissolving the sugar. Sodium silicofluoride is a non-arsenical powder, but if it is not available the lead arsenate can be used as a substitute, but it is more expensive.

Bait tins.—The liquid poisoned bait can be exposed in cigarette tins specially prepared for the purpose. Six vertical cuts about one inch deep are made at intervals in the top edge of each tin and alternate pieces between the cuts are bent outwards to form three horizontal flaps ; the tin is covered to keep out rain and wires are inserted into the pieces between the flaps so that the tin can be hung on to a branch. Each tin is supplied with about 3 oz. of the bait and small strips of cloth or lamp-wick are placed with one end in the liquid and the other end projecting slightly beyond the edge of each flap. The flies come to feed on the wet clothes and then fly away to die elsewhere so that no dead flies will be found in the tins, as in the case of the citronella lure.

2——J. N. 83067 (4/39)

Only about 24 trees per acre need be baited at one time, using one tin per tree, and it is estimated that about 4 pints of bait will be required per acre for each application, using about 3 oz. of liquid per tin. The bait tins should be renewed periodically when they become too rusty inside and the liquid can be replenished as required. The exposure of the poisoned bait in tins insures that the flies have continuous access to the poison, whereas the liquid dries up fairly soon when sprinkled in large drops and may lose some of its effectiveness or be washed off by rain. If an orchard is known to be heavily infested with fruit-fly, it is advisable to bait one-third of the area with tins and to sprinkle at least another one-third periodically in rotation for the first two or three weeks after starting the treatment; a less intensive programme can be carried on thereafter.

Sprinkling.—The same poisoned bait can be applied to the trees with an ordinary garden syringe and the liquid can be squirted into the air so as to fall on the leaves in large drops, and while applying the liquid the operator can walk round the tree. If a syringe is not available, the bait can be sprinkled on to the leaves with a bunch of twigs or a broom. If sprinkling of the trees is considered undesirable, bunches of twigs or bundles of paddy straw can be hung on the trees and sprinkled with the bait. The bait should be used two or three times a week during the early part of the season and once a week later on, if the flies are being controlled. It should be applied during the late afternoon in fine weather and repeated after heavy rain.

It is usually necessary to sprinkle only about one-third of the trees in rotation in any given area, or about 24 trees in an acre of about 70 trees. For each application by sprinkling, one pint of the liquid bait will treat 3 or 4 trees in full bearing, so that this amount will be sufficient for a small garden of about one dozen trees. About one gallon will be required per acre for each application. As regards costs, it is estimated that, using sodium silicofluoride, one gallon of the bait will cost about 7 cents, while with lead arsenate as the poison the cost per gallon will be about 10 cents. One acre can therefore be treated for about 10 cents per application for cost of materials alone. Lead arsenate costs about Rs. 1·50 per lb. and sodium silicofluoride about 50 cents per lb. at Cargills, Colombo, and the cost of freight will have to be added.

The following poisoned bait programme is suggested for an orange grove of ten acres situated in a dry zone district, assuming that the fruiting season starts at the beginning of December and lasts for about four months until the end of March.

The poisoned bait should be started about six weeks before the first fruits are expected to ripen and should be continued for about five months, that is, the baiting season should extend

from about the middle of October until about the middle of March. During the first three months, which are likely to be wet, it is preferable to expose the bait in the tins, so as to protect it as far as possible from heavy rains, and to employ the sprinkling method of application during the last two months, which are normally dry. Advantage can, however, be taken of any dry periods during the monsoon to sprinkle the bait instead of using the tins or to combine the two methods in a more intensive baiting programme.

Approximate cost of baiting in tins.—It has been explained previously that about 24 tins will be needed per acre, or 240 tins for ten acres; also that about 4 pints of bait will be required per acre for each application, or about 5 gallons for ten acres per application. During a tin-baiting season of three months, 24 applications will be necessary at two applications per week, so that 120 gallons of bait will be required for the ten acres for three months. As regards labour, two men for half a day at 30 cents each can renew the bait in 240 tins, costing 60 cents per application, or Rs. 14·40 for the 24 applications during the three months. The following will be the approximate cost for ten acres:—

	Rs.	c.
240 tins cut and fitted with wire at 4 cents per tin ..	9	60
One renewal of 240 tins using old wire at 3 cents per tin	7	20
120 gallons of bait at 7 cents per gallon ..	8	40
Labour for 24 applications at 60 cents a time ..	14	40
	39	60

The cost of baiting 240 tins for the three months is therefore Rs. 4·00 per acre.

Approximate cost of sprinkling.—The bait can be applied for two months during dry weather, and 16 applications will be required at two per week, using one gallon per acre or ten gallons for the whole area per application at 7 cents per gallon. If the liquid bait is sprinkled on to bunches of twigs or bundles of straw hung on the trees, no special apparatus will be required, as a bunch of leafy twigs can be used to sprinkle the liquid. Two men for half a day at 30 cents a man can treat the 240 trees, costing 60 cents per application.

	Rs.	c.
16 applications over ten acres at 70 cents per application	11	20
Labour for 16 applications at 60 cents a time ..	9	60
Total ..	20	80

The cost of sprinkling 240 trees for the two months is therefore about Rs. 2·00 per acre. The total cost of using the two baiting treatments for five months over ten acres will be about Rs. 6·00 per acre. The above cost will be increased to nearly Rs. 7·00 per acre, if lead arsenate has to be used instead of sodium silicofluoride.

It may be mentioned that the fruit-fly poisoned bait should also be useful in controlling the large fruit-piercing moths which puncture the fruit in order to suck the juice. Punctured fruits turn rotten and drop, and the damage is sometimes mistaken for that caused by fruit-flies. The puncture made by the moth can be seen as a small round hole from which juice oozes freely when the fruit is squeezed, but the egg-laying puncture made by a fruit-fly soon closes up and is not noticeable until a small decaying patch begins to form.

3. BAGGING OF FRUITS

In *The Tropical Agriculturist*, February, 1936, pp. 100-101, a note appeared on the bagging of grapefruit and it was stated therein that bagging kept the fruit free from fruit-fly attack and from infection by citrus canker. Further trials made on the Experiment Station, Peradeniya, by the Principal, Farm School, Peradeniya, have indicated that bagging of grapefruit has proved to be quite effective in preventing attack by fruit-fly and that unbagged fruit is usually heavily attacked.

It should be emphasized that bagging alone does not in any way help to control fruit-fly, but merely prevents the flies from laying their eggs in the fruit. Any unbagged fruit is liable to serious infestation. Therefore, if bagging of fruit is employed, it is advisable that other measures, such as the use of poisoned bait and destruction of attacked fruit, should be taken to control fruit-fly.

Usually single fruits are bagged with the smaller size grease-proof paper bag (8″ × 10″) costing Rs. 7·50 per 1,000 or $\frac{3}{4}$ of 1 cent per bag, and approximately two bags are required for each fruit up to the maturity of the same. The cost per bag including twine, labour, &c., is estimated at $2\frac{1}{2}$ cents up to the maturity of the fruit. Sometimes it is necessary to include two or three fruits in a larger bag (12″ × 14″) costing Rs. 10 per 1,000.

4. DESTRUCTION OF ATTACKED AND FALLEN FRUIT

If fruit-fly is to be effectively controlled in citrus and mango areas, it is essential that all attacked and fallen fruit should be collected and destroyed from the time that the first attacked fruit is noticed or the first good-sized fruit has fallen.

This should be done *daily* throughout the fruiting season as a routine measure whether other control measures are employed or not. If regular collection is started early, the daily number to be destroyed should be very small and easily disposed of. All such fruit should be burnt at once or thrown into a kerosene tin of boiling water, so that all maggots still remaining in the fruits are killed. All maggots which escape destruction will pupate in the soil and emerge later as flies to attack any ripening fruit. Large accumulations of attacked and fallen fruit are not only a prolific source of fruit-fly, but cannot be destroyed easily and effectively, and usually the only method available is burial in pits. But burial is not entirely effective, since fruit-flies can emerge through several inches of soil. The systematic and complete destruction of all infested fruit is essential for the success of any other control measures. Therefore all such fruit should be destroyed daily so that it will not accumulate to such an extent as to make its disposal difficult.

DEPARTMENTAL NOTES

PLANT IMPORT LEGISLATION IN CEYLON

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THE purpose of this article is to trace very briefly the development of plant import legislation in Ceylon, indicating some of the more important changes which have occurred since the first steps were taken nearly forty years ago to keep out foreign plant pests and diseases. Special reference will also be made later to the inspection and fumigation work now being done at the new Colombo Port Commission Fumigatorium in respect of both plant imports and exports. In addition to the above type of restrictive import legislation, provision is also made in Ceylon, as in most other countries, for the control by legislative action of certain pests and diseases already established in the Island. But with this aspect of the subject we are not concerned in this article.

In the course of the earlier agricultural development of various countries, involving the importation of many new plants, it may be said that little or no attention was paid to the insect pests, fungous diseases, and weeds which might be brought in with these plant imports. The result of this past indifference has been an unintentional interchange of many undesirable insects and other animals and numerous plant diseases and weeds between most countries. These pests and diseases were able to come in undetected and, as so often happens, became far more serious in their new surroundings than they were in their original homes. It is only within comparatively recent times, that is within the last half-century or so, that the value of legislation for restricting the spread of pests and diseases from one country to another has been recognized. But since the beginning of the present century, the progress made in such restrictive legislation has been rapid, with the result that at the present time it is probable that all countries possessing a permanent organization for the investigation of insect pests and fungous diseases have passed special regulations for preventing, so far as is possible, the introduction of new pests and diseases from other countries. Usually such restrictive legislation not only includes the total prohibition of the importation of certain plants from specified countries, but also imposes certain conditions on the importation of most other plant material.

So far as Ceylon is concerned, one has only to mention such unwelcome importations as the African or Kalutara snail, bunchy top of plantains, water hyacinth, and the coffee berry-borer which have all found a permanent home in the Island to emphasize the necessity for preventing further introductions, such as the cotton boll weevil and the Mediterranean fruit-fly.

PLANT IMPORT LEGISLATION

Ceylon's first plant import legislation came into force on February 28, 1901, when the "Insect Pest and Quarantine Ordinance", No. 5 of 1901, was passed. This ordinance empowered the Governor, with the advice of the Executive Council, to make regulations for preventing the introduction into this Island of insect or fungous pests or plant diseases as well as the spread of such pests and diseases in the Island. Provision was made for "prohibiting the importation into this Island from places beyond sea of any plants" and for cleansing or disinfecting and if necessary destroying without compensation "all plants or the packages, cases, pots or coverings in which they may be packed, which shall be found or suspected to be infected with any insect or fungus or plant disease".

According to Petch (1913), under this ordinance in September, 1901, the importation of cacao plants from any part of the Dutch East Indies was prohibited in order to prevent the introduction of cacao diseases from those colonies, and in July, 1903, the importation of pepper plants into Ceylon from any part of India was prohibited consequent upon serious outbreaks of disease in pepper in South India. Dried seed of the pepper plant for commercial use was exempted from this prohibition. In the above instances total prohibition was considered to be the only possible course at that time, but these prohibitions were removed in 1924.

FUMIGATION OF IMPORTED PLANTS

Petch (1913) states that in 1903 a fumigatorium for the disinfection of plants which might introduce injurious insects was established, and regulations were issued in August, 1903. It was soon found, however, that, owing to the rapid increase of foreign fruit imports, the fumigatorium was too small to cope with the imports at certain seasons without causing serious delay, and the regulations had to be withdrawn. It was not until 1906 that the enlarged fumigatorium at Kochchikade was ready, and an amended set of regulations was issued in July, 1906. These regulations provided amongst other things that most imported living plants, including all citrus fruits, shall,

before being handed over to the consignee, be subject to treatment with hydrocyanic acid gas, or to such other treatment as may be deemed necessary by the Government Entomologist, at the Government fumigatorium at Kochchikade. Potatoes, onions, ginger, turmeric, and culinary vegetables imported for consumption were exempted from the above treatment. It was also stated that "a certificate of fumigation by some properly constituted authority at the port of shipment will be accepted as exempting fruit or plants from further treatment; but a certificate of mere inspection will not be so accepted". As will be seen later, this fumigatorium continued to function until 1927, with certain additions and improvements made to the building at intervals.

In August, 1909, cotton seed was specifically added to the list of plant imports requiring fumigation, and from September 1, 1912, coconuts in husk were allowed in only at the port of Colombo and were to be subjected to fumigation; husked nuts were exempted from treatment. At the present time cotton seed is allowed entry only through the port of Colombo, and any seed or unginned cotton or raw ginned cotton of any species of *Gossypium* grown in the Western Hemisphere is allowed in only through Colombo *viâ* Bombay and must be accompanied by a fumigation certificate from the Bombay Customs. These precautions are taken to prevent the introduction of the cotton boll weevil.

From October, 1910, owing to the spread of Blister Blight in Northern India, it was decided that Indian tea seed, which was then being imported into Ceylon in large quantities, should be imported only through the port of Colombo and be subjected to disinfection with formalin vapour at the Colombo Fumigatorium, unless accompanied by a special certificate that Blister Blight did not exist within a radius of ten miles of the estate or garden on which the seed was grown. These regulations had the effect of limiting the supply of some of the best Indian tea seed and the importations of this seed from India gradually declined from about 5,000 cases in 1912 to about 350 cases in 1920. After it was shown by Gadd (1921) that the disinfection of tea seed as carried out in Colombo was not an adequate safeguard against the introduction of fungus pests with tea seed, the planting community recommended to Government that the importation of tea seed from India, either directly or indirectly, should be prohibited, and this prohibition came into force as from June 30, 1922.

Early in 1919 a half-time Fumigation Officer was appointed and improvements were made to the Fumigatorium during that year. In April, 1920, all the above plant import regulations were brought together under the Insect Pest and Quarantine (Amendment) Ordinance, No. 30 of 1919. Provision was also made in

the regulations for the conveyance of most plant imports to the Kochchikade fumigatorium and for their fumigation or disinfection as deemed necessary by the Director of Agriculture. After treatment and payment of the prescribed fees, the consignee was given a certificate of fumigation and allowed to remove the articles.

In February, 1920, the importation of seeds or plants of *Hevea* (any species) was prohibited, but in 1924 total prohibition was restricted to the Western Hemisphere, while from the Eastern Hemisphere importation was allowed under permit in writing from the Director of Agriculture previously obtained, and these regulations are still in force.

The above-mentioned plant import legislation, which demanded a fumigation certificate from the country of origin or insisted that imports should be fumigated on arrival at Colombo, was continued until June, 1924, when the Plant Protection Ordinance, No. 10 of 1924, was passed. Before commenting on this, a few figures from available records of the amount of plant material imported up to the end of 1924 may be of interest. The records of citrus fruits and miscellaneous plant imports between 1906 and 1911 are no longer available. For the ten years out of the thirteen for which records are available from 1912 to 1924, the average number of cases of citrus fruits treated annually at the fumigatorium was about 650 and of miscellaneous plant consignments about 500. The citrus fruit importations were about double this average for the first two or three years of the above period, but fell considerably below the average between 1915 and 1920.

INSPECTION AND FUMIGATION OF IMPORTED PLANTS

The Plant Protection Ordinance, No. 10 of 1924, continued most of the total or conditional prohibitions of certain plants listed under the previous ordinance. It required amongst other things that all plant imports (with certain exceptions in the case of imports for consumption) from a country whose inspection service is recognized shall be accompanied by an inspection certificate from the country of origin to the effect that such plants were inspected before export and were found to be free from pests and diseases. The presence of such a certificate does not, however, exempt plant imports from inspection on arrival in Colombo from fumigation if found infested and from destruction, if deemed necessary, in order to exclude any dangerous foreign pest or disease. Plant imports from countries where no recognized plant inspection service is maintained or which are not accompanied by a health certificate shall be inspected on arrival and shall receive further treatment, if necessary. By 1924 the issue of health certificates to accompany

plant material from the country of origin was becoming a usual requirement in most countries possessing an organized plant inspection service, and Ceylon, while requiring certificates from certain countries, still retained the right to inspect certified consignments on arrival and to give them any necessary treatment.

This new procedure, involving the inspection of most plant imports, led to a considerable increase in the work of the half-time officer, and it soon became evident that the fumigatorium at Kochchikade was too far away for convenience, apart from its other disadvantages. The construction of a larger building in a more suitable site came under consideration, but meanwhile, in order to avoid undue delay in dealing with the growing volume of plant imports, apart from citrus fruits, during 1925 and 1926, it was arranged that all the smaller packages of plant material should be inspected at the Baggage Office and the General Post Office and only those requiring fumigation be sent to Kochchikade for treatment; all citrus fruits and larger plant consignments were landed direct at Kochchikade for inspection and fumigation if necessary. The situation was further relieved by the appointment of a whole-time Inspector from October 1, 1926, and the above arrangements were continued by him until November, 1927, when a new and enlarged fumigatorium was completed in the Imports Area of the Customs Premises. Since then all plant imports requiring inspection and fumigation have been sent to the fumigatorium for necessary action.

During the five years 1927 to 1931, the citrus fruit imports averaged about 6,470 cases and miscellaneous plants averaged about 1,075 annually. For the next six years (1932 to 1937) the average number of cases of citrus fruit rose to about 9,100, with the record number of 13,581 in 1935, while the other plant consignments increased to about 1,950 annually. Detailed information on the plant imports for the year 1935 was given in an article by Drieberg in *The Tropical Agriculturist*, July, 1936, pp. 12–16.

As a result of the discovery during 1936 of living material of the Mediterranean fruit fly (*Ceratitis capitata*) in certain consignments of citrus fruits on arrival in Colombo, it became necessary to arrange for the inspection on board ship of all citrus fruit imports from all countries bordering on, or situated in, the Mediterranean Sea, and to destroy at sea all such consignments found to be infested with this pest. Consignments found to be free from the fruit-fly were allowed to be landed and, if infested with scale insects, were fumigated. This board ship inspection was subsequently extended to include all citrus fruit imports from other countries known to have the fruit-fly

PLATE 1.—INSPECTION OF IMPORTED FRESH FRUIT AT THE COLOMBO FUMIGATORIUM.

and was carried out until the new plant import regulations came into force on September 30, 1938, imposing certain conditions on the import of all fresh fruit. A copy of these regulations is printed as Appendix A to this article, and it may be mentioned that a departmental note in explanation of them appeared in *The Tropical Agriculturist*, January, 1939, pp. 32, 33.

Meanwhile in 1936, the new Colombo Port Commission Fumigatorium was built in the Exports Area of the Customs premises in order to meet the requirements of the Phillippine Islands that all cases of cacao beans exported from Ceylon to those islands must be accompanied by a fumigation certificate as from January 1, 1937. Detailed information on the plant export fumigation work will be given later, and it will be sufficient to mention here that all plant import inspection and fumigation work has also been accommodated in the new fumigatorium. Since this building is equipped for fumigation with liquid hydrocyanic acid (HCN), the old pot method of fumigation was superseded by this method for the treatment of plant imports as well as exports.

The introduction of the new plant import regulations, involving the inspection of all fresh fruit imported instead of only citrus fruit as under the old regulations, has led to an enormous increase in the import inspection work at the new fumigatorium. For the six months from October 1, 1938, to March 31, 1939, during which these regulations have been in force, the number of fresh fruit packages received at the fumigatorium for inspection and other necessary action was 48,093 as compared with 4,729 for the corresponding period during 1937–38, an increase of more than ten fold. The total number of packages of all plant imports inspected at the fumigatorium during 1938 was 32,515, as compared with 14,633 in 1935, 10,658 in 1936 and 13,676 in 1937. This marked increase is due to the very much larger number of fresh fruit imports which passed through the fumigatorium during the fourth quarter of 1938, as the result of the new plant import regulations. Plate 1 shows the inspection of imported fresh fruit in progress at the Colombo Fumigatorium. The directions issued by the Principal Collector of Customs for the inspection and fumigation of imported plant material during and after office hours are reproduced as Appendix B.

INSPECTION AND FUMIGATION OF EXPORTED PLANTS

By 1924, in view of the adoption in most countries of more stringent legislation to prevent the introduction of pests and diseases from other countries, it became necessary for Ceylon to

make provision for the inspection and fumigation of certain kinds of plant exports and for the issue of health certificates required by other countries. At first these export certificates were issued mainly at Peradeniya to cover all consignments of plant material exported by the Department of Agriculture, while estates desiring to export tea seed to foreign countries were supplied with health certificates after representative samples of their tea seed had been examined at Peradeniya. This plant material intended for export was first inspected by the Mycologist and the Entomologist and fumigated by the latter if considered necessary or advisable ; the covering certificates, signed by both officers, were then issued in duplicate, and this procedure is still being followed.

Prior to 1925 any necessary fumigation was done in the small fumigation chamber then available in the Royal Botanic Gardens, but subsequently fumigation has been carried out in the fumigatorium attached to the Entomological Laboratory. During the first few years an occasional export certificate was issued by the Fumigation Officer in Colombo for consignments which could not be conveniently examined at Peradeniya.

By 1929 the number of packages of exported plants examined at Peradeniya had increased to over 200, and it was in that year that the Inspector, Colombo Fumigatorium, first started the regular issue of export health certificates. During the five years 1930 to 1934, the number of packages of plant exports examined annually at Peradeniya averaged 403, but during the last four years up to the end of 1938 the annual average had dropped to 287, mainly as the result of the increasing number of export certificates issued in Colombo.

As the result of a resolution passed at the Third Imperial Mycological Conference held in London in 1934, a uniform type of health certificate has been adopted for use throughout the Empire. A copy of the Ceylon certificate is given as Appendix C.

The construction of the Colombo Port Commission Fumigatorium in 1936 has led to an enormous increase in the issue of export certificates from Colombo, since these certificates include not only fumigation certificates issued to cover the cacao exported to the Philippine Islands but also inspection certificates accompanying other food products, such as husked coconuts and desiccated coconut, to certain countries requiring such certificates. The following brief notes on this new building and on the process of cacao fumigation may be of interest.

A general view of the building is shown in Plate 2. On the left is an office and a store for chemicals. The main part of the building is divided into four chambers, three of which are devoted for the fumigation of bags of cacao beans prior to export,

PLATE 2.—GENERAL VIEW OF THE COLOMBO CUSTOMS FUMIGATORIUM BUILDING.

PLATE 3.—ARRANGEMENT OF CACAO BAGS FOR FUMIGATION AT THE COLOMBO FUMIGATORIUM.

and the other is fitted for the inspection and fumigation of plant imports. The first chamber on the left has a capacity of 5,200 cubic feet and is designed to accommodate nearly 400 cacao bags. Each of the second and third chambers has a capacity of 12,800 cubic feet and will each hold nearly 1,100 cacao bags. The bags are stocked two bags wide and six bags high, as indicated in Plate 3. This arrangement gives an adequate penetration of gas to all bags.

The fumigant used is liquid HCN which is stored in metal cylinders and is applied under pressure through a pipe connection outside each chamber. The liquid is discharged inside the chamber from pipes on the ceiling in the form of a fine spray which is immediately vaporized under Colombo conditions. The chambers are provided with propeller fans which give an even diffusion of the gas. For the fumigation of cacao bags a dosage of 24 oz. of HCN per 1,000 cubic feet is given for 24 hours and this is followed by a very thorough ventilation of the chamber for 40 hours. Ventilation is carried out by means of suction fans in recessed ducts at the rear of each chamber, and each fan is designed to draw off 1,850 cubic feet per minute. Above the fan is a trap-door sealing the duct during fumigation. After fumigation, the trap-door is opened, the ventilation fan is started and the chamber door in front is unsealed and gradually opened until it is fully opened at the end of 30 minutes. The technique necessary for fumigation with liquid HCN is quite complicated, and under no conditions can the fumigation be carried out by less than two experienced operators.

A weekly fumigation of outgoing bags of cacao beans is given on Fridays, starting at 4 P.M., after the bags have been stacked in the chambers. The ventilation is started at 4 P.M. on Saturdays and is continued until 8 A.M. on Mondays. During dry weather a chamber is usually completely ventilated after about 40 hours, but during wet weather, when the percentage of humidity is higher, it may be necessary to continue the ventilation until the Monday afternoon. Emergency fumigations of cacao bags are sometimes given on Mondays.

During 1937 certificates were issued by the Inspector to cover a total of 59,728 packages of exported plant material. Of this number, fumigation certificates were issued for about 34,500 bags of cacao beans, while the remainder were mostly inspection certificates to accompany the coconut products previously mentioned. In 1938, a total of 83,192 export packages were dealt with by the Inspector, of which nearly 36,000 were cacao bags fumigated prior to export. . Most of the remainder were bags of husked coconuts and cases of desiccated coconut for which inspection certificates only were issued.

ACKNOWLEDGMENTS

The author's thanks for information about the Colombo Port Commission Fumigatorium and about the work carried on there are due to Dr. F. C. Coyne, London Chemist of the Imperial Chemical Industries, Limited, who superintended the equipment of the building, and to Mr. F. D. Peries, Inspector, Colombo Fumigatorium.

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APPENDIX A

"The public are informed that the following regulations have been approved by His Excellency the Governor and will be published in the *Government Gazette* of September 30, 1938, from which date they will begin to operate."

L.D.—B 6/29

THE PLANT PROTECTION ORDINANCE, No. 10 OF 1924.

REGULATION made by the Governor by virtue of the powers vested in him by section 9 of the Plant Protection Ordinance, No. 10 of 1924, and by Article 93 of the Ceylon (State Council) Order in Council, 1931.

B. H. ALUWIHARE,
Acting Minister for Agriculture and Lands.

Colombo, July 22, 1938.

REGULATION.

The regulations set forth in the Schedule to the Plant Protection Ordinance, No. 10 of 1924, as last amended by regulation published in *Gazette* No. 8,276 of March 12, 1937, are hereby further amended with effect from the 30th day of September, 1938, by the substitution, for the regulations contained in Part I. of that Schedule, of the following new regulations :—

"1. (1) No person shall import any plant into Ceylon through any port other than the port of Colombo or the port of Talaimannar : Provided that any of the following articles may be imported through any port, namely,

onions, gingelly seed, dried turmeric, tamarind, " Karanai " roots, groundnuts, paddy, gram, dhal and other pulses, dried chillies, curry stuffs, or other culinary seed.

(2) No person shall import or land a living specimen of any insect or invertebrate animal not already known to exist in Ceylon without the written permission, previously obtained, of the Director of Agriculture : Provided that the Director of Agriculture or the Director, Colombo Museum, may make such importations as may be required for scientific investigations.

2. *Prohibitions and Restrictions.*—No person shall import or land --

(*a*) any seed or plant of any species of *Hevea* grown in the Western Hemisphere ;

(*b*) except under a permit in writing from the Director of Agriculture, any seed or plant of any species of *Hevea* grown in the Eastern Hemisphere ;

(*c*) any tea seed, directly or indirectly, from any place in India, except in such quantities as may be necessary for experimental purposes and except under and in accordance with the terms and conditions of a permit in writing from the Director of Agriculture ;

(*d*) any coconut plant ;

(*e*) any coconut in husk, through any port other than the port of Colombo ;

(*f*) the seed of cotton of any species of *Gossypium*, through any port other than the port of Colombo ;

(*g*) any seed, or unginned cotton or raw ginned cotton of any speices of *Gossypium* grown in the Western Hemisphere, through any port other than the port of Colombo or from any port other than Bombay, or except with a certificate of fumigation or disinfection or both fumigation and disinfection from the Collector of Customs at Bombay ;

(*h*) except under a permit in writing from the Director of Agriculture, any living part of the cassava plant, *Manihot utilissima*.

3. (1) No person shall import any fresh fruit into Ceylon without a licence issued by the Director of Agriculture, or by an officer of the Department of Agriculture authorized in that behalf by the Director, or otherwise than in accordance with the terms and conditions of such licence.

(2) No licence shall be issued for the import of fresh fruit from any country in which the Mediterranean Fruit Fly (*Ceratitis capitata*) or any other pest of fruits which has not become established in Ceylon is known or suspected to exist unless the Director of Agriculture is satisfied that either before export from such country or during transit to Ceylon the fruit is so treated as to ensure that such pest, in all its stages, is effectively destroyed.

(3) Every licence issued under this regulation shall—

(*a*) specify the country from which the fresh fruit may be imported ;

(*b*) be valid for the period specified in the licence ;

(*c*) be subject to the condition that it may be withdrawn by the Director of Agriculture at any time prior to the expiry of that period by written notice addressed to the holder of the licence ;

(*d*) be subject to such other special conditions as may be set out in such licence by or by the authority of the Director of Agriculture ; and

(*e*) be in the form set out hereunder :—

"THE PLANT PROTECTION ORDINANCE, NO. 10 OF 1924.

Licence to Import Fresh Fruit.

Under regulation 3 of the regulations set forth in Part I. of the Schedule to the Plant Protection Ordinance, No. 10 of 1924, as amended by regulation published in *Gazette* No. ——— of ———, ——— (name) ——— of ——— (place) ——— is hereby licensed to import the under-mentioned varities of fresh fruit from ———

This licence expires on ———.
This licence is subject to the condition that it may be withdrawn by the Director of Agriculture at any time prior to the date set out above by written notice addressed to the holder of this licence.
This licence is further subject to the special conditions set out overleaf.

———,

——— (date) ———. (for) Director of Agriculture."

(4) No person shall land any fresh fruit at any port other than the port of Colombo, and no person shall land such fruit at Colombo, unless he has satisfied the Principal Collector of Customs that such fruit was grown in and consigned from the country specified in the licence issued to that person.

4. *Inspection, Fumigation, and Disinfection.*—(1) All living imported plants, coconuts in husk, and the seed of all species of *Gossypium*, shall before passing out of the Customs, be examined by the Inspector in charge of the Colombo Fumigatorium, together with the packings, cases, pots or coverings in which they may be packed : Provided that this paragraph shall not apply to potatoes, onions, turmeric, culinary seed, edible vegetables, and the seed of such vegetables and the seed of any ornamental plant.

(2) Every imported plant, which on inspection is found or suspected to be infected with any pest or disease, shall be subjected to fumigation or disinfection, or both fumigation and disinfection, as may be deemed necessary by the Inspector : Provided that the Director of Agriculture, by notification published in the *Gazette*, may direct from time to time, that all imported plants of any species or genus, or all plants of any specified species or genus imported from any specified part of the world, shall be subjected to fumigation or disinfection or both fumigation and disinfection ; and after the publication of any such notification all consignments of the plants referred to therein shall be subjected to fumigation or disinfection or both fumigation and disinfection, as the case may be.

(3) Where fumigation or disinfection is necessary, such fumigation or disinfection shall be carried out at the Colombo Fumigatorium.

(4) The Director of Agriculture may order that any plant which has been fumigated or disinfected shall be grown for a period of quarantine in special nurseries provided or approved by him for that purpose.

(5) Every plant which is to be fumigated or disinfected under this regulation shall, after it is landed at the Customs premises, be conveyed to the Fumigatorium under Customs supervision at the expense of the consignee or his agent.

(6) As soon as possible after the receipt of any imported plant or package of imported plants at the Fumigatorium such plant or package shall be examined by the Inspector and fumigated or disinfected or both fumigated and disinfected, as the circumstances may require.

(7) After examination and any necessary treatment, the articles shall be delivered to the consignee together with a certificate showing that they have been dealt with as required by this regulation.

(8) No person shall remove any article from the Fumigatorium until he has obtained the certificate referred to in paragraph (7).

(9) The certificate referred to in paragraph (7) shall not be granted until all fees due in respect of supervision and fumigation have been paid in such manner as the Principal Collector of Customs may direct.

(10) Fumigation or disinfection shall be carried out at the risk of the consignee, and the consignee or his agent shall be in attendance during the process of unpacking the articles for inspection, fumigation, or disinfection and of repacking them thereafter, and shall provide the labour necessary for handling the articles during such processes.

(11) Where any plants are sent to Ceylon through the Post Office from a place beyond Ceylon the plants shall be conveyed to the Fumigatorium under the supervision of the Postal Authorities at the expense of the consignee or his agent and shall be examined by the Inspector and dealt with as prescribed in the foregoing paragraphs.

(12) The consignee shall pay in respect of each plant or package conveyed to the Fumigatorium—

(*a*) where it is conveyed under the supervision of the Customs Authorities, a supervision fee of Re. 1 for any period from 9 A.M. to 4 P.M., together with a further fee calculated at the rate of 25 cents per hour for any period between 4 P.M. and 9 P.M.; and

(*b*) where it is conveyed under the supervision of the Postal Authorities, a supervision fee of 50 cents for any period from 9 A.M. to 4 P.M., together with a further fee calculated at the rate of 25 cents per hour for any period between 4 P.M. and 9 P.M.

(13) The consignee shall, in addition to the fee specified in paragraph (12) pay a fee of 25 cents per package to cover the cost of fumigation or disinfection.

(14) Any imported plant which in the opinion of the Inspector cannot be cleaned by fumigation or other treatment shall, together with the packings, cases, pots or covering in which it may be packed, be destroyed at the expense of the consignee."

APPENDIX B

Directions made by the Principal Collector of Customs in terms of Regulation 4 (9) of the Regulations made under section 9 of the Plant Protection Ordinance, No. 10 of 1924, dated July 22, 1938, and published in Government Gazette No. 8,399 of September 30, 1938

CUSTOMS NOTIFICATION (GENERAL) NO. 39/2

Part I.—Inspection and Fumigation during Office Hours

1. Whenever plants, fruit, or seeds, requiring examination or fumigation before delivery are imported in any other way than by post, the consignee or

his agent will hand in an application in the prescribed form at the Baggage Office and pay a fumigation fee of 25 cents per package.

2. The Charges Officer will enter in a register to be maintained for the purpose all fumigation fees received, and account for such fees as in the case of his other daily takings at the Baggage Office.

3. After the Charges Officer has registered the form and endorsed due receipt of the fee, it will be sent to the Inspector, Fumigatorium.

4. When plants and seeds are landed outside the Exports premises (*e.g.*, at Kochchikade or Indian Goods Shed) and conveyance to the Fumigatorium involves removal outside the Customs premises, the usual fee of Re. 1 to cover Customs supervision will be payable by the consignee or his agent.

5. For each plant or package sent to Ceylon by post and conveyed to the Fumigatorium under the supervision of the Postal authorities a supervision fee of 50 cents for any period from 9 A.M. to 4 P.M. will be recovered from the consignee or his agent. If the plant or package is fumigated the fumigation fee of 25 cents per plant or package will also be recovered. The fees referred to in this paragraph will be recovered by the postal authorities at the time of delivery of such plant or package.

6. The fumigatorium labourer will attend the Baggage Office at 10 A.M. on Saturdays and at 10 A.M. and 2 P.M. on other week days, to remove for examination or fumigation packages landed there by passengers or sent in the sealed van from Talaimannar.

Part II.—Inspection and Fumigation after Office Hours.

1. Application for inspection or fumigation after the usual office hours should be made to the Inspector, Fumigatorium, within office hours.

2. If packages are conveyed under Customs supervision after 4 P.M. a fee calculated at the rate of 25 cents per hour is payable in addition to the charges payable under paragraphs 1 and 4 of Part I.

3. If packages are conveyed under the supervision of the Postal authorities a fee calculated at the rate of 25 cents per hour for any period between 4 P.M. and 9 P.M. on week days is payable in addition to the charge payable under paragraph 5 of Part I. Postal packages are not conveyed to the Fumigatorium on Sundays or Post Office holidays.

4. If packages are delivered on Sundays, Customs Holidays, after 2 P.M. on Saturdays or after 4 P.M. on other week days, a delivery charge of 75 cents per hour will be made.

5. In addition to the charges mentioned above fees at the rate of Rs. 2·85 an hour for the attendance of the Fumigation Inspector, and cents 35 an hour for the attendance of a labourer are payable for the period during which their services are required for inspection and/or fumigation of consignments at any time on Sundays and Public Holidays, and outside the hours of 9 A.M. to 1 P.M. on Saturdays and 9 A.M. to 4.30 P.M. on other week days. When the services of the Assistant Fumigation Inspector are in addition necessary, a charge of Re. 1 an hour for his services will be made.

The Notification dated March 20, 1936, and published in the *Ceylon Government Gazette* of March 20, 1936, is hereby repealed.

H. M. Customs,
Colombo, January 18, 1939.

H. J. LEIGH-CLARE,
Acting Principal Collector of Customs.

APPENDIX C.

DEPARTMENT OF AGRICULTURE, CEYLON

Certificate of Examination of Plants for Export.

THIS is to certify that the living plants or plant products ——————————————————— [1] included a representative sample of the living plants or plant products in the consignment of which particulars are given below were/was [1] thoroughly examined on the [2] ———— by[3] ———(*a*) duly authorized official(s) of the Department of Agriculture, Ceylon, and found to be healthy, no evidence of the presence of any injurious insect, pest, or disease having been found in/on [1] them and that the consignment (including the packing) covered by this certificate has/has not [1] been treated in the following manner [4] ————

prior/immediately subsequent [1] to inspection.

Inspected/Not inspected [1] in the field by a duly authorized Inspector on [2]————.

Signature : ————.

Official status : ————.

Date : ————.

No. and description of packages : ————.

Distinguishing marks : ————.

Description of living plants or plant products or parts thereof : ————.

Stated to be grown at ————.

Exported by ————.

Name and address of consignee : ————.

Name of vessel or particulars of route : ————.

Date of shipment : ———— Port or place of entry : ————.

Additional certificate(s) attached : ————.

(Give here details of any special certificate or certificates issued in respect of imports specifically scheduled by the importing country.)

[1] Strike out the words not applicable.

[2] Date.

[3] Name.

[4] *e.g.* fumigated with — or disinfected with ————.

SEASONAL PLANTING NOTES

T. H. PARSONS, F.R.H.S.,
CURATOR, ROYAL BOTANIC GARDENS, PERADENIYA

IT has been decided to publish a monthly calendar of seasonal planting notes and cultural operations prepared to suit the conditions prevailing in the different zones of the Island, but modifications according to elevation and local conditions should rest with the discretion of the individual gardener.

For major products it is always advisable to carry out all planting during the two monsoons, *i.e.*, South-West in May-June and North-East in October-November, but for flowering annuals of different types which only last for a limited period, of approximately 3 months or so, it is found more practicable to grow them throughout the year in rotation to be in flower successively. This is more easily done in the wet zones which benefit from both monsoons, but in the North and other dry areas this practice is generally limited to the North-East monsoon period.

CALENDAR OF WORK FOR MAY

In the South-West monsoon portion of the Island this month is probably the busiest. It follows the normally dry period of February-March with light showers of April not sufficient in themselves to warrant planting or replanting operations of perennial plants.

In the flower garden all beds and borders can now be overhauled, forked and manured and new plantings made in anticipation of the South-West monsoon rains to consolidate and start off vigorous growth. *Cannas* are best planted in the months of May and November and should be given planting distances of 1½ to 2 feet apart, with ample supplies of cattle manure, for they are gross feeders. The first flowers appear from 5 to 6 weeks from planting and they remain in flower normally for a period of 6 months from planting. If they are not then replanted, *i.e.*, in November, they rapidly begin to deteriorate.

Avoid planting in the actual rainy periods and wait sufficiently long for the rain-water to drain away. This may be only an hour or two in light soils or a day if the soil is of heavy texture.

Perennials and shrubs of all kind can then be planted, such as cuttings or rooted plants of Pentas, Dahlias, Ground Orchids, Coleus, Roses, Crossandra, Gerberas, Ixora, Hibiscus, Iresine, Gynura, Acalypha, Brunfelsia, Strobilanthus, Poinsettia, Lantana, Bougainvillaea, Clerodendron and the like. Annuals however dislike the heavy rainy periods and need planting out from boxes or pans after the worst of the monsoon is over and are more suitable for June and July plantings. Exceptions, however, are Gynandropsis, Balsams, Sunflower, and Torenia which are more hardy than the normally cultivated annuals. Ordinary annuals such as Asters, Phlox Drummondii, Anthusa, Zinnia, Marigold, Hollyhock and the like may now be sown in pans or boxes and kept under partial cover for later planting.

Planting of new hedges are best made in May, trenches 1½ feet wide by 1½ feet deep having previously been prepared and refilled with the addition of cattle manure at the rate of one cart load to 10 yards of trench. Suitable subjects for hedges are Hibiscus (Shoeflower), Duranta, or Acalypha by cuttings inserted in two rows, 9 inches apart and 12 inches between cuttings. Madras Thorn is very suited to low-country and to dry and semi-dry zones, and is best raised by sowing seeds *in situ* at distances of 3″ apart in the row and in 3 rows, each 6 inches apart. A pound of this seed costs no more than a rupee and the seed being small—4,000 seed to the lb.—one pound is sufficient for roughly 100 yards of hedge. It is by far the most economic form of hedging but takes time to reach the required dimensions. Another slow but very effective hedge is formed with *Cupressus macrocarpha*—a conifer—which is well suited to elevations above 1,000 feet and up to 6,000 feet. Established plants in baskets are necessary and should be planted in 2 rows 18″ apart and 3 feet apart in the row.

Where the gardener desires to grow his own requirements for his garden, the May monsoon conditions should be utilized for growing stocks of most shrubs and perennials. A corner of the garden should be devoted to nursery purposes and cuttings of many shrubs and perennials can easily be rooted for later planting into beds and borders. The essentials of a nursery bed are a porous soil of good humus content to which is added a good quantity of sand. Sand is in fact very essential to encourage rooting. The cuttings should normally be 8″ to 10″ long and must be cut cleanly across a bud (node) with a sharp knife and all leaves taken off to prevent evaporation of the moisture or sap in the cutting. There are, however, many forms of cuttings some being soft-wooded such as the geranium, others partially ripened wood such as the Hibiscus (Shoeflower) or rose, some hard-wooded such as Ixora, Ceylon Myrtle and the like; whilst others like Begonias can be rooted from leaves

or a portion of the leaf only. Generally, however, most plants propagate best from fully-matured shoots, known by the term "hard wood" cuttings.

In the low country and with the cooling South-West monsoon conditions fresh sowings of beans, cauliflowers and most root crops can now be made. If it has not already been done, sweet potatoes for August-September crops, ginger for December yields, onions, bandakai, brinjals and chilli plantings may also now be made. Put in supports for all yams.

In up-country districts, vegetables such as peas, broad beans, onions must await drier conditions, but french beans, cabbage and other green stuff, with many root crops, can be persevered with though they are liable to be damaged by strong winds and rains which generally continue throughout May, June and July.

Seasonal fruits in market this month include Mangoes, Cashew, Guava, Jak, Limes, Oranges, Mandarins, Grapefruit, Mangosteens (early), Papaw, Pine apples and Plantains.

Lawns should receive treatment at this period, all worn patches being cut away and re-turfed, the soil being forked up before laying the sods. Where a fairly large area has to be repaired, it should be cleansed and well loosened with a garden fork and a layer of leaf-mould or other form of humus incorporated. The surface should then be raked over, all stones removed and root sections of local grasses dibbled in at 3 to 4 inches apart.

White ants become very troublesome at times in the monsoon period but they are readily dealt with by closing all outlets excepting one through which petrol—a quarter of a cigarette tinful for a normal termite mound—is poured, sealing the remaining openings immediately the petrol has been poured in.

SELECTED ARTICLES

REJECTION OF THE FIRST-DRAWN MILK*

DAIRY farmers' troubles in regard to milk and cream quality usually begin in the cowbail at milking time. It is an unfortunate fact that bacteria of the types most harmful to keeping quality are always to be found in and around the milking shed. They may find their way into milk from many sources—the cow's coat and udder, dried dust and manure, the milker's hands if he neglects to wash them, or the milk utensils.

An additional source of contamination, which is often overlooked, is the small quantity of milk always present, even immediately after milking, within the narrow canal leading from the udder to the outlet of each teat. Here, bacteria entering from outside through the teat opening as soon as the cow lies down, and finding nourishment and a suitable medium and a temperature for growth, may multiply and become established in enormous numbers in a few hours. Especially in the case of older cows, where the udder muscles have become slack, the bacteria can penetrate very easily into the teat canal through the enlarged opening.

The first operation, therefore, in clean milk production is the thorough washing of the outside of the cow's udder and teats, and the second is the removal of this first-drawn or " foremilk " so that it does not add large numbers of bacteria to the milk. Two or three streams of milk drawn off into a separate vessel before starting milking into the pail (or before affixing the machine) will be sufficient to wash the teat canal free, or almost free, of contaminating organisms.

The following figures, which are the results of experiments carried out to show the relative average numbers of bacteria found in the first, middle and the last-drawn portions of milk from a herd of twelve cows, show clearly the advantage of rejecting the first streams of milk, as well as of grooming the cows and keeping the surroundings clean :—

	Foremilk.	Middle.	Last drawn.
Cows not prepared and shed neglected	26,450 per c.c.	5,880 per c.c.	9,250 per c.c.
Cows groomed, shed neglected	13,720 per c.c.	2,430 per c.c.	3,130 per c.c.
Cows neglected, shed cleaned	13,260 per c.c.	2,200 per c.c.	1,550 per c.c.
Cows and shed cleaned	6,420 per c.c.	1,220 per c.c.	1,720 per c.c.

(Ref. Grant Lockhead, Department of Agric., Dominion of Canada.)

The work of many investigators shows that almost invariably the foremilk is the most heavily contaminated portion, though results and opinions vary as to the distribution of bacteria throughout the remainder.

* By M. J. Griffith, B.Sc., Dairy Bacteriologist (Dairy Branch) in the *Queensland Agricultural Journal*, Vol. LI., Part I, January, 1939.

It used to be thought that cleanly-produced milk must be almost sterile and that all bacteria found in it were from outside sources, but with the advance of dairy science it has been proved that the natural " count " of milk varies enormously according to the individual cow, and that milk as it comes from the udder is rarely, if ever, completely free from bacteria. Some representative results are given below :—

	Foremilk.	Middle.	Strippings.
Harding and Wilson (average of 5 cows over 6 days) ..	458 per c.c. ..	187 per c.c. ..	274 per c.c.
Orla-Jensen (1 cow) ..	16,000 per c.c. ..	480 per c.c. ..	360 per c.c.
Copeland and Olsen (8 cows) ..	5,989 per c.c. ..	557 per c.c. ..	415 per c.c.

One American worker (Stocking), quoted by Hammer, tested the different streams of milk to find out the extent of the heavy preliminary contamination, with the following results :—

Trial Numbers.	Streams 1 and 2.	5 and 6.	9 and 10.	13 and 14.	Strippings.
1	.. 1,940 per c.c...	550 per c.c...	250 per c.c...	275 per c.c...	216 per c.c.
2	. 25,200 per c.c...	5,391 per c.c...	285 per c.c...	218 per c.c...	101 per c.c.
3	.. 5,491 per c.c...	2,096 per c.c...	430 per c.c...	820 per c.c...	141 per c.c.
4	.. 7,941 per c.c...	1,350 per c.c...	125 per c.c...	216 per c.c...	156 per c.c.

These figures show the substantial decrease, even in very clean milk, after four streams have been removed. The reduction in count obtained by discarding the first three streams of milk from each teat has been found to amount to about 4 per cent. of the whole milking. (Ref. Hammer, " Dairy Bacteriology.") This quantity does not at first appear to be very significant, but a consideration of the types of bacteria present will show its importance. In the foremilk are mainly soil and water organisms and coliform types which are injurious to milk, whilst the flora of the middle and last-drawn portions of milk consists of inert udder types which are natural inhabitants of the normal healthy udder and are not undesirable in milk or harmful to its quality. For the production of clean milk to be used for human consumption, rejection of the first-drawn milk is obviously of assistance in maintaining a high standard of purity and good keeping quality ; but in the case of milk production for butter or cheese making also, the practice has more advantages than disadvantages.

The most important reason why *every* farmer should make a practice of removing the foremilk regularly morning and evening is that it enables him to notice anything abnormal in the appearance of the milk. Signs of mastitis usually show up in the form of tiny clots or strings in the first-drawn milk, which, if observed, may mean the early detection of the disease in animals having one or more affected quarters. Special care may then be taken to milk these infected cows last ; their milk can be isolated from the rest, and the spread of the disease can be arrested. Neglect or ignorance of mastitis infection, however, in its early stages may have serious and far-reaching effects on the individual cow, on the bulk milk, and on other animals in the herd. A word of caution is necessary as to the method of removing this first-drawn milk. Under no circumstances must it be withdrawn on to the floor of the milking shed, for this is one of the surest ways of spreading any infection that may be present. Apart from this, decomposition will take place, with accompanying bad smells and attraction of flies.

On many modern milk-producing farms in England a " strip-cup " is used, consisting of a small vessel fitted with a black-enamelled lid, over which each stream of milk passes before flowing through a hole into the cup below. This makes it possible to see at a single glance, if any quarter is yielding stringy or abnormal-looking foremilk, and with such a system in use at each milking a case of mastitis cannot become advanced without the knowledge of the milker. Any ordinary small pail or billycan will, of course, serve the purpose, but it should be kept for this only and washed and scalded daily.

The foremilk will not amount to a great quantity except in the case of a large herd, but if it is free from any signs of disease it can be used for calf or pig feeding. It is advisable to pasteurize or bring it up to boiling point and cool before using. If it contains milk from several diseased cows, it is advisable to dispose of it, after adding some disinfectant, by emptying *well* away from the cowbails and water supply. The pail should then be washed, scalded thoroughly, and rinsed with disinfectant.

It is well known that the highest percentage of butterfat in milk is found to be contained in the strippings, and that the first-drawn milk is the poorest portion, showing the lowest butterfat and the highest water percentage. Average analyses of the milk of seven cows, made by Eckles, showed only 10·67 per cent. of milk solids to be present in the foremilk, compared with 14·86 in the strippings, the difference consisting almost entirely of fat. Thus thorough stripping of every cow (done gently and not by downward jerking of the udder) will bring its own reward in the form of increased butterfat yield and stimulation of secretion by the milk glands ; whilst the loss in butterfat occasioned by removing the first few streams of milk is negligible, and the slight reduction in the quantity is more than offset by the improvement in keeping quality of bulk milk.

FOOD IN THE TROPICS*

ONE of the things that strike the Westerner forcibly when he visits the tropics is the food—not so much the food the Europeans eat as that on which the natives live. In Europe he was used to meals consisting largely either of bread or meat and vegetables, supplemented by milk, eggs, fruit and so forth. Observing the native in the warong, he notes that the meal the man orders consists of a large quantity of rice, a small piece of dried fish, some vegetables—invariably well-seasoned with Spanish pepper—and a number of native delicacies. There are a great variety of these side-dishes. In his book on "*Food in the Netherlands Indies*" Dr. Van den Burg mentions hundreds of different kinds. Often these are prepared by the help of micro-organisms, as for instance in the case of *tempe kedeleh*, which is made by allowing a certain mould to act on soy beans. Then there is *ontjom*, which consists of *bungkil cachang tanah*, (peanuts from which all the oil has been pressed out and that has stood long enough to become covered with a fungus, white or a fine orange as the case may be; and *trassi* which is made on a large scale in Siam and Bagan Si-api-api simply by allowing half-dried fish to rot. Besides these delicacies natives eat fruit all the year round, mostly bananas, but also papayas, dukus, mangoes, durians (which smell of garlic), mangistans, and various other kinds. In some parts of the Indies rice is entirely or partly replaced by maize, sago, or cassava root.

Nowadays particularly in the great sea-ports and nearby cities the food available for Europeans differs very little from that which one gets in Europe. But this condition of things is only of quite recent date. It is but fifteen or twenty years ago that fresh yeast was first brought over in cold storage by the mail steamers. Before that time people were obliged to use a kind of leaven containing, besides alcohol and carbonic acid producing yeast, other micro-organisms that form lactic acid and the like, the result being that bread always tasted more or less sour. Add to this the fact that the tinned butter was generally rancid, and it becomes easy to understand why many Europeans preferred dishes made chiefly of rice to meals consisting largely of bread. Nor is it very long ago that potatoes and fresh vegetables became obtainable in sufficient quantities in the coastal towns. Before the supply of these was plentiful many Europeans were simply forced to have recourse to the native "rijsttafel". During the last few decades life has been very much Europeanized with the result that, at least in the large cities, Europeans can live on the diet they were accustomed to in their native country. There is, however, one important article of food which is still much more difficult to get in the Indies than in Europe, particularly in the plains—namely, fresh milk. But

* By Dr. B. C. P. Jansen in the *Bulletin of the Colonial Institute of Amsterdam*, Vol. II., No. 1, November, 1938.

apart from this difficulty the Westerner need suffer no deprivation in respect to diet. So when we speak of tropical diet, we mean native diet, which certainly differs very greatly from the diet usually adopted by the inhabitants of cooler regions.

The next question which arises concerns the comparative food values of these very different diets. The science of dietetics is endeavouring to find an answer to this question. The history of this science very much resembles that of several other branches of natural science. In the course of last century our knowledge was enormously increased and consolidated, but further research has taught us that we overrated our powers and are much further from a final solution of the problem than was considered possible in the early days. The giant strides taken in the nineteenth century in this matter of dietetics was the discovery that the components of food-stuffs are classifiable under four heads, namely, proteins, fats, carbohydrates and salts. The importance of this achievement should not be underestimated. It made possible a comparative study of tropical diet, the diet of the Eskimo and that of the dwellers in the temperate zone.

Twentieth century research has shown us that previous results were only approximately true. Yet these latter retain their value for all that, and we may now ask: what of the food-value of tropical as compared with European diet, when judged by dietetic principles of the nineteenth century.

Let us begin by considering the total bulk consumed daily by the individual. On the ground of superficial investigations, students were at first inclined to assert that natives of the tropics eat much less than persons born in regions more to the South or more to the North. A deeper study of this question has, however, brought to light that the total quantity consumed by a human being doing a certain kind of work in the tropics is the same as that taken by his fellows of a similar trade or profession in other parts of the world. Careful investigations made as far back as the latter part of last century in Java by Eykman, and again a few years ago by Teding van Berkhout and Radsma, established this fact.

So much for the quantity eaten, but what about the relative proportion of the protein, fats and carbohydrates consumed? On this point, too, research was at first superficial. Analysis revealed the fact that rice is very poor in protein, and as rice is the staple food of most tropical peoples, it was generally assumed that their diet must be very much lacking in protein. Once more it was Dr. Eykman, who by his careful researches proved that in this respect, too, the diet of the tropics differs very little, if at all, from that of Europe.

To repeat: according to the old standard dietetics the diet prevailing in the tropics does not differ appreciably either in quantity or value from that of temperate climes. As we said above, however, this teaching is only approximately true. The conclusive proof that the old views were in need of modification and supplementation was given by Eykman and Grijns as a result of their study of a tropical disease, namely beri-beri. Until the end of the nineteenth century this complaint was believed to be traceable to a bacterial cause. In the course of his experiments with hens Dr. Eykman discovered that these were subject to a disease greatly resembling beri-beri. This disease

did not appear to be caused by bacteria, however, but came from feeding on machine-polished rice. Dr. Eykman asked himself, whether this might possibly be the cause of beri-beri in human beings too? Experimentation on human beings was of course impossible, but in spite of this difficulty an answer was found to this question.

A new method of research was adopted. There were at the time certain prisons in Java where serving a sentence of more than three months was equivalent to death. For all the inmates of these particular institutions developed beri-beri in the course of time and the disease invariably proved fatal. Dr. Eykman was, of course, aware of these facts and asked his friend Dr. Vorderman, (who in his capacity of Inspector in the Public Health Department was medical supervisor of prisons) on the one hand, to investigate the beri-beri question and on the other to find out what kind of rice was given to prisoners in Java. The researches which followed brought to light that—

(*a*) in prisons where the rice was milled by hand, and where consequently part of the embryo and of the outer pellicle were preserved, beri-beri hardly occured at all, while

(*b*) in prisons where the inmates were fed on machine-polished rice from which the embryo and outer coating had been entirely removed, the death-rate from beri-beri was disproportionately large.

These facts proved without the shadow of a doubt, that this deadly disease of beri-beri was the result of eating too highly polished rice.

Further investigations made by Dr. Grijns showed that beri-beri is due to the lack of a certain substance which he called " protective substance " and which is present in the outer layers and the embryo, but not in the body of the rice kernel. Later Dr. Funk re-named this substance a " vitamin". Researches made during the last twenty-five years have established the fact that not one, but a large number of these protective substances are necessary for human food—that there are a number of different vitamins, in fact.

The actual quantity of the vitamin needed is extremely small, amounting to only one in a million parts of food, but the presence of this infinitesimal quantum is absolutely necessary. Lacking these vitamins in his diet a man is sure to develop one or more of the fatal diseases to which the general name avitaminoses or deficiency diseases has been given.

To return to the question of tropical diet—how does it stand with regard to vitamin-content ?

As we saw above, there is a disease in the Indies which is unknown in the Netherlands, namely, beri-beri. Formerly this disease occurred chiefly among what Van Dieren called "government boarders", soldiers, prisoners, coolies working in the tin mines, hospital patients, and the like. Since half-polished rice has been substituted in the diet of these groups for the machine-polished variety—thanks to the work done by Eykman and Grijns—beri-beri has entirely disappeared.

In the dessas, as villages are called in the Indies, where the farmers mill their own rice, beri-beri is unknown. In the large centres it is otherwise. Here we find the disease still ocurring regularly. Nor will it be a simple matter

to extirpate it. The Americans have, indeed, repeatedly suggested at Congresses of the Far Eastern Association of Tropical Medicine that the preparation and import of highly polished rice should be made illegal. Such a measure would indeed be decisive, but the proposal has again and again been rejected, and rightly so in my opinion, for the simple reason that it is unworkable. Not only does the native town-dweller prefer nice-looking, white, highly polished rice from a culinary point of view, but there is another reason why this kind of rice is more popular, namely, that the semi-polished is a very poor trade commodity. It does not keep well and in a very short time it develops a musty, rancid taste which makes it uneatable. Possibly, in the course of time, some way will be found to supply even persons living on highly polished rice with the necessary anti-beri-beri vitamin, for last year science succeeded in making this protective substance synthetically both in the laboratory and in the Factory.

And what about the other so far discovered vitamins in the tropics ?

Up to the present there is only one form of avitaminosis known in Europe, namely rickets. This disease is caused by the lack of a substance which has been given the name of vitamin D. Cod-liver oil is especially rich in this vitamin. This oil is not used in the tropics and yet we do not find rickets there. It now appears that vitamin D is easily produced in the skin when the latter is exposed to rays of a certain wave-length known as ultra-violet. The Tropical sun sends forth these rays in great profusion ; the few rays of sunlight that reach us in the course of a Dutch winter hardly include any at all. This explains why rickets occur in Holland but not in the tropics, except in certain parts of India where the purdah system prevails ; where, in other words, women go out very little and never in public without a veil, with the result that they absorb very few ultra-violet rays.

Another important vitamin is the one named A. If this is insufficiently represented in a man's diet he is apt to develop an eye-disease known as xerophthalmia. This complaint may lead to blindness or even death, if the diet is not corrected. Xerophthalmia does not occur in the Netherlands. In the Indies it is not uncommon, however, and Dr. Theijsson, the well-known ophthalmologist, holds that a large proportion of the cases of blindness found in that part of the world is due to this complaint. Vitamin A, which, as remarked above, wards off this disease, is contained in cod-liver oil ; it is also found in such foods as milk (butter) and eggs ; and further in green vegetables and fruit. It appears, however, that this vitamin as it occurs here is rather difficult to digest, and that therefore the body only profits by a small proportion of that which is present in the food. Obviously, then, it is by no means impossible that the native menu may often be deficient in this particular " protective substance".

The above has shown that when one of the vitamins is entirely, or almost entirely, lacking in our diet, the result is a deficiency disease which almost always terminates fatally. Now none of these real deficiency diseases, except rickets, occur in the Netherlands, nor do we find them in the Indies except sporadically. But another question arises. What happens when the menu is so composed that, while all are present, one or more of the vitamins is not

represented to just the right extent? On this point we have as yet little know ledge, as researches in this direction were undertaken only very recently. One thing has, however, come to light already, namely, that in our own, as in other countries, the vitamin supply in many cases is not sufficient. To mention one case in point, it is very likely that many of the troubles common in pregnancy are traceable to a slight insufficiency of the anti-beri-beri vitamin. Matters may be improved by substituting brown bread for white in the diet. We do not know how conditions are in the Indies in this particular respect. Some research work is already on foot in the Archipelago, however.

This is being carried out by the Institute for National Nutrition which was established a few years ago with the help of the Queen Wilhelmina Jubilee Fund. One of the lines along which useful results have been obtained is that of a comparative study of native diets, in different parts of Java. We have every reason to expect that the activities of this Institute will throw light on the question raised above.

We may say, then, that as far as our present knowledge goes there is no difference between the diet of the natives in the Indies and that of the peoples of the temperate zone as regards the total quantity consumed. Nor do these two diverge to any great extent in the matter of protein content. But when it comes to those subtler components we call vitamins a distinct difference is noticeable. No one living in the tropics need fear that he will suffer from a lack of the anti-rickets vitamin, for the sunlight of the country he inhabits will ensure a sufficient supply of it in his skin by the action of the ultra-violet rays. On the other hand, the fact that in big towns in the Indies large quantities of machine-milled rice are consumed, means constant danger of beri-beri attacking him, and furthermore one is more likely to suffer from a lack of vitamin A—*i.e.*, the anti-xerophthalmia vitamin—in the tropics than in Western Europe.

As regards the more elusive question of the exact amount of proteins, fats, carbohydrates, vitamins and various inorganic salts needed to build up the ideal diet, and what the relative proportions of these different elements should be—we have hardly begun looking for the answer to it either in the Indies or in Europe.

MEETINGS, CONFERENCES, &c.

RUBBER RESEARCH SCHEME (CEYLON)

MINUTES OF THE FORTY-SEVENTH MEETING OF THE RUBBER RESEARCH BOARD HELD IN THE CEYLON CHAMBER OF COMMERCE BUILDING, COLOMBO, AT 2.30 P.M. ON WEDNESDAY, MARCH 15, 1939

Present.—Mr. E. Rodrigo, C.C.S. (in the Chair); Mr. I. L. Cameron; Mr. L. M. M. Dias; Mr. L. B. de Mel, J.P., U.P.M.; Mr. F. H. Griffith, M.S.C.; Mr. R. C. Kannangara, M.S.C.; Mr. J. C. Kelly; Mr. F. A. Obeyesekera; Mr. J. L. D. Peiris.

Mr. T. E. H. O'Brien, Director, was also present by invitation.

Apologies for absence were received from Mr. C. H. Collins, C.C.S., Deputy Financial Secretary; Mr. L. P. Gapp; Mr. B. M. Selwyn; Mr. E. C. Villiers, M.S.C.; and Mr. E. W. Whitelaw.

1. MINUTES

Draft minutes of the forty-sixth meeting which had been circulated to members were confirmed and signed by the Chairman.

2. BOARD

(*a*) The Chairman reported that he resumed duties as Chairman of the Board with effect from March 1, 1939.

(*b*) The Chairman also reported that :—

1. Mr. J. C. Kelly had been renominated by the Ceylon Estates Proprietary Association to serve for a further period of 3 years with effect from March 5, 1939.

2. Mr. E. C. Villiers, M.S.C., had been nominated as a representative of the State Council with effect from March 3, 1939, in place of Mr. R. P. Gaddum who had resigned.

(*c*) Referring to the *impending departure on furlough of Mr. Griffith*, Mr. De Mel proposed a vote of appreciation of the valuable services rendered by Mr. Griffith as a member of the Board and as Chairman of the Experimental Committee. Mr. Obeyesekera seconded. Carried with applause.

3. EXPERIMENTAL COMMITTEE

Recommendations made at meeting held on February 28, 1939 :—

(*a*) *Dartonfield Water Supply.*—Decided to augment the water supply at Dartonfield by the construction of a well in the watershed below the factory. A vote of Rs. 1,912·45 was approved to cover the cost.

(*b*) *Visiting Agent's Report.*—The Visiting Agent's report of his inspection of Dartonfield and Nivitigalakele on January 28, 1939, was adopted and it was noted with satisfaction that he was pleased with the way the estates were being worked.

(*c*) *Training in Estate Works.*—Decided that it would not be practicable to give training in general estate works and that such training did not properly come within the scope of the Scheme's activities.

(*d*) *Additional Assistant for Chemical Department.*—Decided to authorize the appointment of an additional assistant for the Chemical Department on the usual salary scale and conditions of service for junior officers.

(*e*) *Boiler.*—The recommendation of the Committee that a new boiler be purchased at a cost of Rs. 1,650 was approved.

4. ACCOUNTS

(*a*) *Statement of Receipts and Payments of the Board* for the quarter ended December 31, 1938, was adopted.

(*b*) *Statement of Receipts and Payments of the London Advisory Committee* for the year ended December 31, 1938, was adopted.

(*c*) *Balance Sheet and Auditor's Report for 1938.*—The balance sheet and auditor's report for 1938 were considered and adopted. The following figures summarize the financial position :—

			Rs.
Income 1938			179,401
		Rs.	
Expenditure 1938 :	Revenue	165,039	
	Capital	51,969	
			217,008
Available cash balance			133,307

(*d*) *Over-expenditure of Votes.*—Covering sanction was given for over-expenditure of votes totalling Rs. 2,313. It was noted that the over-expenditure was covered by savings under other votes.

(*e*) *Revotes for 1939.*—Unexpended balances of 1938 capital votes amounting to Rs. 8,690 and revenue votes amounting to Rs. 294, were revoted for the current year.

(*f*) *Inventory Report for 1938* was adopted.

(*g*) *Dartonfield and Nivitigalakele Accounts for November and December, 1938,* were tabled.

(*h*) *Investment of Funds.*—On the recommendation of the Committee appointed at the last meeting to advise on the investment of funds it was decided to confirm the policy laid down at a Board meeting held in October, 1937, namely, " that a sum approximating to the balance of the Depreciation and Provident Fund Reserves should be invested, provided that the sum so invested shall not exceed 50 per cent. of the Board's total funds, and that it be left to the Chairman to make suitable investments in consultation with the Deputy Financial Secretary ".

The Chairman was authorized to take the necessary steps to implement the policy.

(*i*) *Employees' Provident Fund.*—Decided to amend rule 1 to provide :—

(*a*) That all employees drawing a salary of Rs. 40 per month or over shall become members of the Fund.

(*b*) That monthly paid employees on a lower salary than Rs. 40 per month may become members of the Fund after completion of a period of six months' service.

5. REPORTS

(*a*) Technical officers' reports for the 4th quarter, 1938, were adopted.

(*b*) Annual Report for 1938 was adopted after minor alterations had been approved.

6. STAFF

(*a*) *Re-engagement of Small-holdings Propaganda Officer.*—Reported that the 4-year period for which Mr. W. I. Pieris had been engaged under his present agreement would expire on May 31, 1939. Decided that Mr. Pieris be offered re-engagement for a further period of 4 years, and that four months' leave on full pay be granted at the termination of the present agreement. Further decided that Mr. C. A. de Silva, Assistant Botanist, should take charge of the work of the Small-holdings Department during Mr. Pieris' absence.

(*b*) *Field Assistant for Geneticist.*—Reported the appointment of Mr. E. B. Gnanaratnam as Field Assistant to the Geneticist on the usual salary scale for junior officers.

The meeting terminated with a vote of thanks to the Chamber of Commerce for the use of their Committee Room.

Research Laboratories,
Dartonfield,
Agalawatta.

March 29, 1939.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD AT THE GRAND ORIENTAL HOTEL, COLOMBO, ON FRIDAY, MARCH 31, 1939

Present.—Mr. James Forbes (Chairman), the Hon. the Financial Secretary (Mr. H. J. Huxham), the Director of Agriculture (Mr. E. Rodrigo), the Chairman, Planters' Association of Ceylon (Mr. R. C. Scott), the Chairman, Ceylon Estates Proprietary Association (Mr. R. J. Hartley), Messrs. I. L. Cameron, J. D. Hoare, J. C. Kelly, S. F. H. Perera, Gordon Pyper and Dr. R. V. Norris (Director and Secretary), and by invitation Dr. C. H. Gadd.

Major J. W. Oldfield and Mr. T. B. Panabokke had both intimated their inability to be present.

1. The Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board held on December 22, 1938, were confirmed.

MEMBERSHIP OF THE BOARD AND COMMITTEES

3. *Board.*—(*a*) Reported that Mr. Gordon Pyper had been nominated by the Planters' Association of Ceylon to act as a member of the Board during the absence of Mr. R. G. Coombe (Letter dated January 31, 1939, from the Secretary, Planters' Association of Ceylon).

(*b*) Reported that Mr. I. L. Cameron whose nomination as a member of the Board expired on January 27, 1939, had been renominated by the Ceylon Estates Proprietary Association for a further period of 3 years as from that date. (Letter dated March 3, 1939, from the Secreary, Ceylon Estates Proprietary Association).

The Chairman congratulated Mr. I. L. Cameron on his renewed nomination and welcomed Mr. Pyper to the Board.

Experimental Sub-Committee.—Mr. J. D. Hoare was invited to act on the Experimental Sub-Committee during the absence of Mr. R. G. Coombe on leave.

FINANCE

4. (*a*) *Audited Accounts for 1938 and Auditors' Reports.*—The Chairman said the audited accounts for 1938, of which members had copies, had been considered by the Finance Sub-Committee together with the Auditors' Reports. The reports were of a very satisfactory nature indeed and reflected credit on the Director, Superintendent and the office staff. It was gratifying to note that the various changes previously recommended by the Auditors in the Estate Accounting methods were all working smoothly and had received favourable comment by the Auditors.

The question of insurance cover which was referred to by the Auditors had been considered by the Finance Sub-Committee who were satisfied that the present cover was adequate.

The Audited Accounts for 1938 and the Auditors' Reports thereon were approved by the Board.

(*b*) *Institute's Accounts for January and February, 1939.*—These were approved without comment.

ST. COOMBS ESTATE

5. (*a*) Visiting Agent's Report dated December 16, 1938.

(*b*) Minutes of the 40th Meeting of the Experimental and Estate Sub-Committee held on January 28, 1939.

The Chairman suggested these be considered together.

Desmodium gyrans.—In reply to a question Dr. Gadd said there was nothing to add in regard to the position of this plant in relation to eelworm.

Clearings.—The Chairman referred to the failure of the N. E. Monsoon and the severe drought experienced in Dimbula which had seriously prejudiced the success of the clearing.

In reply to Mr. Cameron and to Mr. Scott, the latter of whom favoured the use of basket plants, the Director said that seed-at-stake, 4 seeds to the hole, had been used in order to provide a basis for selection. This consideration had rendered the use of basket plants impracticable.

Mr. Perera expressed doubt as to the advisability of using Vigna on the clearings and the *Chairman* said further details would be obtained before this was done.

Mr. Cameron asked if lime-washing was to be recommended for dealing with lichens and moss. Dr. Gadd replied that he thought this practice was of little use and that removal of lichen and moss was best done by hand. Mr. Scott concurred.

In reply to Mr. Hoare who asked if *Tephrosia vogelii* was to be used on the clearing, the Chairman pointed out that the Experimental Sub-Committee had recommended the use of Crotalarias and *Desmodium gyrans.*

(*c*) *Sanitary Inspector's Report, St. Coombs Estate.*—The Chairman reported that the inspection was carried out on 15th February and the report was satisfactory. Items requiring attention were of a minor character and would mostly be carried out this year, any matter outstanding being provided for in 1940 estimates.

TEA RESEARCH INSTITUTE CONFERENCE

6. The *Chairman* said that the recent Conference which had been well attended was very successful and read the following extract from a letter he had addressed to the Director on the subject :—

> "I write to convey to you and your staff an expression of my appreciation and admiration for the excellence of all the Papers and arrangements at the recent Conference. I think the organization from your end was beyond all praise and I will be glad if you will convey my feelings in the matter as above to all those concerned. I think everyone is agreed that it was the best and most interesting Conference we have so far held."

The Board endorsed the opinion expressed by the Chairman.

Arising from the Director's address, *the Chairman* said various suggestions had been made in regard to additional Conferences or Meetings between the Institute's Staff and representatives of District Planters' Associations in order to maintain contact in the intervals between the main Conferences. A letter on the subject had been received from the Planters' Association of Ceylon and a Memorandum drawn up by the Director had been circulated to members.

Victoria Commemoration Bdg.
P. O. Box No. 42,
Kandy, February 22, 1938.

The Chairman,
Tea Research Institute of Ceylon,
Thornfield,
Agrapatna.

Sub-Conferences.

DEAR SIR,

MY Chairman informs me that at the Tea Research Institute Conference on the 13th instant it was suggested that each District P. A. should nominate two members to represent their Districts, who could attend Sub-Conferences in the event of any pest or disease of tea being prevalent in their Districts. For instance at the moment phloem necrosis seems to be prevalent in the Kandapola District and it is thought that a sub-Conference between representatives of the Nuwara Eliya District P. A. and an officer or officers of the T. R. I. might be beneficial to all concerned.

Before bringing the suggestion to the notice of this Association's General Committee, the Chairman would like to know as soon as possible if the Board of Management of the T. R. I. approve of this suggestion.

A further suggestion is that a small sub-Committee of Representatives of Up, Low and Mid-Country, C.E.P.A., and T.R.I. with power to co-opt others should be formed, thus enabling matters of interest to be discussed as and when advisable and thus maintain interest during the two year intervals between Conferences.

Yours faithfully,
ARTHUR W. L. TURNER,
Secretary.

CONFERENCES

(1) In my address at the recent Conference I invited opinion on the following suggestions :—

(*a*) That periodical meetings might be held at St. Coombs as occasion arose between the Scientific Staff and representatives nominated by the Planters' Association and the various District Associations, the object being to secure the closest liaison between the Institute and Districts.

(*b*) The holding of occasional small Conferences to discuss in some detail any special problems of immediate topical interest.

(*c*) That two days per month be set aside for Visitors to St. Coombs instead of one at present.

In regard to (*a*), there seemed to be general agreement that such arrangements would serve a useful purpose. It was suggested each district might nominate two representatives for the purpose, but not necessarily the same men on each occasion, the choice of persons being determined by the nature of the problem to be discussed.

In regard to (*b*) it was pointed out that if attendance at proposed small conferences were open to all, there would be no guarantee that the meetings would in fact be restricted in size and the object of the proposal might thus be defeated. This objection seems sound.

(2) An alternative suggestion put forward was that, in order that matters on which there were belived to be differences of opinion might be thrashed out, the staff should have round-table discussions with selected agricultural experts interested. This would be feasible though the selection of those who should attend would possibly be a matter of some delicacy.

(3) Mr. Scott has suggested the formation of a small standing Sub-Committee containing representatives of Up, Mid, and Low-country, the Ceylon Estates Proprietary Association and the Tea Research Institute with power to co-opt others to enable matters of interest to be discussed as and when advisable between main conferences.

Mr. Scott will no doubt indicate in more detail the function of this proposed Committee. It might perhaps serve the purpose indicated in paragraph 2.

(4) Yet another suggestion put forward is that meetings should be arranged between Tea Research Institute's Staff, Visiting Agents and Colombo representatives.

(5) A further point for consideration is whether the interval of two years between main Conferences is too long. One suggestion put forward is that Conferences should be held each year, but that in alternate years the place of Meeting should be somewhere, possibly Kandy, more convenient for Mid and Low-country planters than St. Coombs.

(6) It seems probable that some development on the lines indicated above may prove desirable but care should be taken to ensure that the Conferences, Sub-Conferences, Round-Table Talks, &c., all of which require considerable preparations, shall not absorb an undue proportion of the time of the technical staff.

(7) I have not dealt in this note with the question of the internal arrangements for the Conferences. The experience of the last Conference suggests, however, that more time must be available for actual discussion which can be achieved either by limiting the number of papers dealt with or by issuing the papers *in extenso* before the meeting when they would be taken as read.

(8) Arising from the last Conference, reference must be made to the questions of special advisory officers and instructional courses.

The amount of advisory work continues to increase. At the present rate some reorganization will in the not distant future have to be considered.

Financial considerations would, however, appear to rule out the appointment of any additional staff for advisory work.

The question of instructional courses was mentioned by me at the Conferences. I have not been approached further on the question by the Ceylon Planters' Society and the matter was only taken up by one speaker at the Conference who thought the courses would have to be too limited in scope to serve a very useful purpose.

ROLAND V. NORRIS,
Director.

March 20, 1939.

Enlarging on his memorandum, *the Director* said there seemed to be a considerable measure of agreement that some kind of Liaison Committee consisting of the Tea Research Institute Staff, representatives of District Planters' Associations and of Colombo would serve a useful purpose in promoting closer contact between the Institute and Districts. Such a Committee would naturally meet only infrequently but the organization would be available if anything of importance occurred which required joint consideration.

There was also the question of providing facilities for discussion in detail of problems on which differences of opinion might exist.

Mr. Scott had also suggested the formation of a standing committee and he would no doubt indicate what the function of this Committee would be.

In regard to the question of Conferences at places other than St. Coombs, the Director said he thought there was a good deal to be said in favour of this proposal.

Mr. Scott said he thought the interval of two years between Conferences was too long unless arrangements were provided to maintain contact meantime between the Institute and Districts. He strongly favoured setting up a Committee on the lines suggested. Such a Committee might meet once, or possibly twice, a year. It would not, therefore, cause undue interruption in the Institute's work but would keep the Institute and planting representatives in touch.

Mr. Kelly thought a liaison committee would be unnecessary as it would always be possible when occasion arose for Districts to ask the officers of the Institute to meet them in conference and it would be equally easy, when the desire was felt by the Institute, to ask the District or Districts to appoint representatives to discuss a particular problem with the Scientific Officers. In this way the necessary conference could be arranged without the intervention of a liaison committee.

The Director explained the procedure in regard to the Conferences held at Tocklai which, he stated, were not open to all but confined to the Tocklai Staff and nominated representatives of planting districts and Calcutta.

Mr. Cameron was doubtful how far the suggested Committee would serve the purpose desired and thought better results could be obtained by lectures and visits by the Staff in the districts.

The Chairman, in reply to Mr. Cameron, pointed out that the present proposals were to be additional to lectures and visits which were already provided.

Mr. Cameron asked whether in this case interference to research work would result.

Mr. Scott suggested that in regard to lectures, those attenting were not perhaps always prepared to express an opinion at short notice on the issues raised. In the case of meetings held by the suggested Committee, representatives would come with definite instructions and it would be possible to reach some conclusion.

The Chairman said there seemed to be agreement in principle to the setting up of Machinery to maintain contact between Conferences. He personally wished to stress the importance of close liaison between the Institute, Visiting Agents and Colombo Firms.

The views expressed by members of the Board would now be considered and he and the Director would later make more specific proposals.

DISEASES AND PESTS

7. (*a*) *Phloem necrosis.*—The Board considered a resolution from the Nuwara Eliya District Planters' Association suggesting that additional staff should be engaged to enable more intensive work on Phloem necrosis to be carried out.

After discussion the Board approved proposals made by the Mycologist for the organization of such work and agreed to approach the appropriate Authorities in England to explore the possibility of obtaining the temporary services of a trained Research Scholar to carry out histological and cytological investigations in connexion with this disease.

(*b*) *Tortrix.*—Reported that the recommendation made by the Institute in regard to the temporary suspension of the regulations concerning Tortrix made under the Plant Protection Ordinance has been approved both by the Planters' Association of Ceylon and the Central Board of Agriculture.

The Director of Agriculture said he would take the necessary steps at an early date to give effect to this recommendation.

SENIOR SCIENTIFIC STAFF

8. Reported that Dr. Tubbs, Plant Physiologist, proceeded on home leave on March 1.

JUNIOR STAFF PROVIDENT FUND

9. Mr. Kelly was elected to act as a Trustee during the absence of Mr. R. G. Coombe on leave.

ANY OTHER BUSINESS

10. (*a*) Reported that the Draft Report of the Board for 1938 was approved by circulation of papers (Circular No. A 5/39 dated March 2, 1939).

(*b*) Reported that the Guest House was now open.

(*c*) *Research on the Chemistry of Tea.*—Reported that the Advisory Committee in London had recommended that Dr. A. E. Bradfield, D.Sc., of the University of Wales, Bangor, be appointed as Research Chemist under the scheme for Research on the Chemistry of Tea. It was suggested that Dr. Bradfield, after preliminary work under Dr. Lampitt and in a Tea Brokers Office, should work in a University Laboratory in London, probably at the Imperial College.

The Director said Dr. Bradfield seemed very suitable for the appointment and suggested the Board should confirm the selection, at the same time emphasizing that the Board's contribution to the scheme was limited to a payment of Rs. 5,000 per annum for five years. No guarantee could be given as to the position after that period as this would depend on the financial resources of the Institute at the time.

The Board agreed that the Director should write to the Ceylon Association in this sense.

The meeting then concluded with a vote of thanks to the Chair.

ROLAND V. NORRIS,
Secretary.

April 24, 1939.

REVIEW

Statistical Technique in Agricultural Research.—By D. D. Paterson. McGraw-Hill Publishing Co., Ltd., London, 1939. 18s.

AGRICULTURISTS who are familiar with Mr. Paterson's expositions of field experimentation methods in *Tropical Agriculture* will welcome this more ambitious venture of his. Mr. Paterson aims at satisfying a demand which exists among research workers for an elementary presentation of statistical methods. His book with its lucid exposition of fundamental statistical concepts and its numerous, elaborately worked out, illustrative examples—many of them drawn from the author's well known work on tropical fodders—unquestionably achieves this end. The opening chapter includes discussions of normal distributions, standard deviation, standard and probable errors, the analysis of small samples and methods of computation. Chapter 2 deals at considerable length with the analysis of variance. This early treatment of the analysis of variance is a novel and, in a book addressed primarily to the field experimentalist, a desirable departure from the usual text-book practice. The reader will probably find the author's indiscriminate use of Snedecor's F and the now obsolescent z value of Fisher, rather disconcerting. Statistical constants like the probable error, Fisher's z and Student's z may conveniently be allowed to lapse into disuse. The frequent application of the analysis of variance to discontinuous, non-normal distributions has been a feature of recent biological work—the reviewer himself is not without sin in this respect—and example 9 in chapter 2 appears to be an instance of this inappropriate use. Asymmetric distributions of the binomial or Poisson type should undergo a logarithmic, square root or inverse sine transformation before they can be validly subjected to an analysis of variance and to relevant tests of significance. The chi-squared test is dealt with in chapter 3 and the use of diagrams in chapter 4. Chapters 5 and 6 provide excellent discussions of the use of correlation and regression. The remainder of the book (chapters 7–9) is devoted to an account of the technique and design of field experiments. Problems of plot technique including questions of optimum size, shape and arrangement of plots, come up for discussion. Simple and complex randomized block and Latin square layouts and confounded designs are illustrated with full arithmetical working of the examples, and the use of the analysis of covariance in error reduction and methods of estimating values of missing plots are explained. Chapter 8 on serial and perennial crop experiments is of especial interest to workers in the tropics. The author states in chapter 9 that " confounding is only practicable in relatively complex factorial experiments embracing several different

problems concurrently." A species of confounding is, however, adopted in the quasi-factorial designs developed by Yates for testing out large numbers of varieties of a crop plant. Confounding represents an attempt at a reduction of block size and a consequent reduction of error variance. The question of block size comes up with considerable urgency in paddy varietal trials in Ceylon where the size of fields is a serious limiting factor. In these circumstances, unorthogonal designs of the quasi-factorial type are the most efficient ones available. Mr. Paterson may with advantage include in the next edition an account of the use of these quasi-factorial designs in varietal trials. The "selected bibliography" of 65 titles is rather inadequate: the valuable text-book on *Methods of Statistical Analysis* by C. H. Goulden is omitted and Fisher's book is miscalled *The Design of Field Experiments*. The book closes with an appendix of statistical tables and a satisfactory index. Misprints and mistakes are scarce; the value of t on page 109 should be 2·807 instead of 2·87, and on page 218, *Table 80* should be substituted for *Table 78*. The book has the familiar and handsome format of McGraw-Hill publications.—M. F.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED APRIL 30, 1939

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1939	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Piroplasmosis	2	..	..	2	..	..
	Rabies	2	1	..	..	..	2
	Rinderpest	9	..	..	2	..	7
	Blackquarter	1	..	1	..	..	..
Colombo Municipality	Foot-and-mouth disease	25	..	2	22	..	1
	Anthrax	1	1	1	..	..	..
	Rabies	1	1	1	..	..	..
	Piroplasmosis	3	..	..	3	..	..
Cattle Quarantine Station	Foot-and-mouth disease	1	..	..	1	..	..
	Anthrax	29	3	29	..	..	..
Central	Foot-and-mouth disease	83	4	..	79	4	..
	Anthrax	1	..	1	..	..	..
	Rabies	8	1	2	..	..	6
	Contagious mange	18	6	2	6	10	..
	Blackquarter	8	..	8	..	..	..
	Piroplasmosis	5	..	1	4	..	..
Southern	Rabies	1	..	..	..	..	1
Northern	Foot-and-mouth disease	130	..	7	123	..	..
Eastern	Foot-and-mouth disease	2	..	..	2	..	..
North-Western	Foot-and-mouth disease	122	..	3	119	..	.
	Rabies	1	..	..	..	..	1
North-Central	Foot-and-mouth disease	1,307	19	..	1,288	19	..
Uva	Foot-and-mouth disease	58	..	4	54	..	..
Sabaragamuwa	Haemorrhagic Septicaemia	1	..	1	..	..	..

Department of Agriculture,
Peradeniya May 17, 1939.

A. JAYASINGHA,
for Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, APRIL, 1939

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	87·2	—0·4	76·1	+0·3	74	91	7·5	10·67	24	+ 1·79
Puttalam ..	88·1	—1·0	75·8	—0·1	76	91	6·5	7·04	14	+ 2·15
Mannar ..	89·2	—1·6	77·9	—0·1	76	89	7·5	14·79	10	+ 11·66
Jaffna ..	88·9	—0·5	79·9	—0·1	76	85	5·4	13·20	7	+11·71
Trincomalee ..	88·1	—0·9	77·2	—0·4	74	89	5·4	4·18	10	+ 2·19
Batticaloa ..	87·6	—0·1	76·8	+0·2	76	91	5·6	6·78	9	+ 5·03
Hambantota ..	86·8	—0·8	76·5	+0·4	78	91	5·8	10·48	15	+ 7·17
Galle ..	85·3	—0·9	76·8	+0·2	79	88	6·0	7·91	16	— 0·87
Ratnapura ..	89·8	—1·3	74·1	+0·3	78	95	7·4	15·08	25	+ 3·84
Anuradhapura ..	90·1	—1·0	76·9	+2·2	72	95	6·5	17·33	20	+11·47
Kurunegala ..	89·3	—1·6	74·4	—0·1	74	95	8·0	13·62	24	+ 4·17
Kandy ..	86·0	—1·8	70·0	+0·1	78	95	7·0	15·02	24	+ 8·79
Badulla ..	81·8	—2·3	66·6	+0·5	77	97	6·2	14·76	24	+ 8·34
Diyatalawa ..	77·1	—0·8	62·0	+1·9	76	89	7·5	14·46	21	+ 9·22
Hakgala ..	73·5	—0·6	56·4	+1·6	80	91	6·5	12·54	21	+ 5·40
Nuwara Eliya ..	70·0	—1·4	52·0	+2·8	80	94	8·4	10·94	23	+ 6·28

After six consecutive months of dry conditions, April enjoyed an excess rainfall. A few stations, mainly in the western low-country areas, recorded slight deficits, however, the largest being 4·91 inches at Gookiyanakanda. Excesses over 15 inches were common in the central hill country and the neighbourhood, the largest being 23·36 inches at Galawela 22·13 inches at Upper Ohiya and 20·03 inches at West Haputale.

The highest monthly totals were 36·30 inches at Yatiyantota and 34·60 inches at Haputale, while totals of over 30 inches were recorded at Lemastota, Diyatura, Wahacotte, Upper Ohiya, West Haputale, and Giniheriya. The lowest total for the month was 3·10 inches at Kal Aar, while a few other stations mostly in the Trincomalee District also recorded totals of less than 5 inches for the month.

There were altogether 136 daily falls of over 5 inches during the month, the majority of them on the 11th and 12th. The highest daily falls reported (excluding an abnormal figure at Talaimannar, the correctness of which is now under examination) were 12·35 inches at Mannar Waterworks and 12·32 inches at Jaffna Farm School, both on the 12th.

During the first third of the month the weather was more or less of the inter-monsoon type with weak barometric gradients. Thunderstorm activity was well in evidence and accounted for an appreciable amount if irregularly distributed rain. On the 11th the pressure fell and conditions became unsettled. On the following day a depression was identified to the east of Ceylon. This moved in a north-westerly direction, intensified into storm and crossed the Indian Coromondel Coast near Cuddalore on the evening of the 13th. Thereafter it gradually weakened and filled up.

As a result of this depression, heavy widespread rain occurred over the Island on the 11th and 12th, particularly the latter day, when some very heavy falls were reported from the north and north-west.

During the second half of the month, the weather reverted to the inter-monsoon type. The pressure gradients were generally flat, while thunderstorm activity became once more faily pronounced. On the last two days of the month, a moderately steep south-westerly gradient developed, an indication of the temporary advance of the south-west monsoon.

Temperatures were below normal by day, and generally about normal by night, the only noteworthy exception being the minimum temperature upcountry which was above normal. Humidity and cloud amount were both in excess. The barometric pressure was below normal, particularly in the eastern half of the Island. Winds were above normal strength, the direction being generally variable.

A hailstorm was reported from Hakgala on the afternoon of the 26th.

H. JAMESON,
Superintendent, Observatory.

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EDITORIAL

CINCHONA

FROM the first introduction of the cinchona tree to the East, the British and the Dutch authorities pursued two divergent policies. The chief aim of the British authorities was not the isolation of any of the alkaloids present in the cinchona bark all of which were known to be febrifugal nor the standardization of a refined product containing some or all of them in fixed proportions for the purpose of commerce, but the provision of a cheap and abundant supply of the bark containing these alkaloids so that a reasonably efficient febrifuge might be brought within the reach of all classes of the people. The Dutch, on the other hand, never lost sight of the fact established as early as 1820 that quinine was the principal alkaloid derivative from the cinchona bark and that it might become an article of commerce in the world market. They concentrated all their efforts on the establishment of a strain which yielded a high percentage of quinine. These efforts were supplemented by the advantage of superior soil and climatic conditions and by the wisdom of the Netherlands authorities who were more prompt than the British in acquiring the seed of the new variety *Ledgeriana*, named after Clements Ledger who first brought it to Europe. Thus it came about that, within 25 years of the introduction of the first cinchona plant, Java was producing a bark with a quinine content of 11 per cent. and above, while the average in the Ceylon plantations was less than 2 per cent. : and when the great slump of 1882 came only the Dutch industry survived.

The plantations in Java were able to meet the whole of the world's demand for quinine, and there was no reason to expect that that source of supply would dry up, and the British Empire's dependence on Java for her requirements became a complacent habit until there was a threat of a second catastrophe during the period 1909–1912. The price of bark fell to a unit rate of 3 cents and this was quite unremunerative especially at a time when other forms of tropical agriculture had reached the peak

of prosperity. It was rumoured that Java would retire altogether from the industry, and the Empire countries became uneasy; the Government of India began to think of making that country self-supporting. But with the formation of the Kina Bureau in 1913 the Dutch industry revived, and the war interrupted the plans for the establishment of large plantations in India.

More recently the Imperial Government examined the problem from a different point of view. It was laid down by the Secretary of State that "every practicable measure should be taken to extend the benefits of anti-malarial treatment to a larger proportion of the population of the Empire", and he was "most anxious that quinine or other cinchona derivatives should be more readily available to a greater percentage of those who would benefit by their use than is the case at present". Under the stimulus of this interest of the Imperial Government, Ceylon has now for about 4 years been exploring the prospects of a revived local cinchona plantation industry. Last year an officer of the Department of Agriculture visited India and Java to study the problems connected with cinchona growing and his recommendations are now before Government.

The Imperial Council of Agricultural Research has just issued a valuable report* by Mr. A. Wilson on the "prospects of cinchona cultivation in India" which, read with the report of the Cinchona Sub-Committee of the Imperial Council of Agriculture and Animal Health, would be most useful in helping Ceylon to come to a decision regarding her policy. The following appear to be the considerations which may govern this policy :—

(1) The prospect of finding a place in the world market
(2) The provision of cheap quinine or of a cheap and abundant febrifuge other than quinine for the masses
(3) Imperial policy of making the Empire independent of foreign supplies
(4) The prospect of establishing a remunerative local industry behind a protective wall.

It is futile to attempt to compete with Java in the world market. She can easily meet the whole of the world's demand since she now meets over 90 per cent. of it with a restricted output of 52 per cent. of the possible maximum in existing plantations: and a country that burns as useless all bark with a quinine content of less than 6 per cent. (when the content of the greater part of the Indian bark was only 5 per cent.) can easily drive all competitors out of the market by a temporary reduction of price.

The price of the article forms a comparatively small fraction of the cost involved in the administering of quinine to the

* *Miscellaneous Bulletin* No. 29.

poorer classes in the remote parts of the country and it is improbable that more of it will reach those who can benefit by its use if the price is reduced by half. Febrifuges prepared from low-quinine-yielding species of cinchona are not likely to be received more favourably in Ceylon than tota-quina was in the African Colonies where, according to the Cinchona Sub-Committee, the inhabitants were reluctant to accept mixtures made up with tota-quina.

It is hardly practicable or appropriate to discuss Imperial policy here; but it may be suggested that, so long as Java retains her present political status, it is unlikely that Ceylon will have occasion to regret its dependence on a foreign country.

There remains the question of a remunerative local industry. The present consumption of cinchona in the Island is about 17,000 lb. per annum. Assuming a consumption of 20,000 lb., the value of the quinine imported annually is Rs. 440,000. In the case of a small country like Ceylon this is not an inconsiderable volume of trade. If suitable land is available and a reasonably good variety can be grown in Ceylon, Indian experience shows that the article can be produced for sale at the present market price with a very good profit. This market price is Rs. 22 per lb. We feel some embarrassment in stating the Indian cost of production, because paragraph 5 of *The 75th Annual Report of the Government Cinchona Plantation and Factory in Bengal* gives the "total cost per lb." as Rs. 6·192, while paragraph 84 of Mr. Wilson's report estimates it at Rs. 14·875. Even if the latter and larger figure is accepted, the margin of profit is considerable. But cinchona is not a crop which we can recommend to the private planter even with this expectation of profit. The experience of India as recorded by Mr. Wilson shows that this is a most delicate plant requiring the most careful handling, and that it is impossible to determine in advance from general principles whether it would thrive in any particular site. The path of the cinchona grower is bound to be attended with trial and disappointment. The only suggestion that the circumstances justify is perhaps that Government should establish State cinchona plantations for the limited purpose of creating a local industry.

CEYLON'S COCONUT CROPS

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EXPORT figures of coconut products provide almost the only means of ascertaining with any degree of exactness the trend of coconut production in Ceylon. Acreage statistics available are not much more than rough estimates; of the total acreage probably not more than 25 per cent. is under estate cultivation; and of this 25 per cent. only a lamentably small proportion is under such management that crop returns are likely to be very accurate.

The export figures have therefore received critical attention on several previous occasions. In *The Tropical Agriculturist*, September, 1919, H. K. Rutherford compared the exports of coconut produce for the periods 1911–1914, and 1915–1918; in *The Tropical Agriculturist*, May, 1923, he gave also the figures for 1919–1922.

Mr. (now Sir Frank) Stockdale continued this critical examination in an article in *The Tropical Agriculturist*, December, 1927, and it is the purpose of the present article to present the export figures for 1911–1938 in the form adopted by Rutherford and Stockdale, the object being the same as in their articles, namely to elucidate the trends of Ceylon coconut production during the periods reviewed.

The export figures given are from the Customs returns. As in the previous articles referred to, the figures have been grouped into four-yearly periods, to average out to some extent the effect of variation of climate.

TABLE I.

Exports of Coconut Produce from Ceylon

Year.	Oil Tons.	Copra Tons.	Desiccated Tons.	Coconuts.
1911	25,251	41,091	14,610	15,723,393
1912	20,089	30,704	13,940	16,010,809
1913	27,349	55,865	15,190	16,861,324
1914	24,314	70,597	15,593	11,429,594
Total	97,003	198,257	59,333	60,025,120

TABLE I.—*contd.*

Export of Coconut Produce from Ceylon—*contd.*

Year.		Oil Tons.		Copra Tons.		Desiccated Tons.		Coconuts.
1915	..	25,075	..	60,426	..	17,450	..	5,827,669
1916	..	16,151	..	65,497	..	15,307	..	4,694,297
1917	..	21,735	..	53,935	..	13,603	..	5,289,481
1918	..	26,374	..	63,616	..	10,168	..	6,553,278
Total	..	89,335		243,474		56,528		22,364,725
1919	..	33,800	..	87,976	..	33,753	..	3,390,710
1920	..	25,376	..	67,893	..	25,937	..	9,776,479
1921	..	24,236	..	68,372	..	43,526	..	23,738,542
1922	..	27,731	..	84,329	..	38,411	..	22,317,747
Total	..	111,143		308,570		141,627		59,223,478
1923	..	24,027	..	50,773	.	40,940	..	15,693,670
1924	..	27,631	..	88,459	..	43,567	..	29,121,041
1925	..	30,890	..	113,686	..	39,708	..	23,288,786
1926	..	28,523	..	120,970	..	37,718	..	16,951,368
Total	..	111,071		373,888		161,933		85,054,865
1927	..	33,658	..	99,107	..	43,641	..	18,875,750
1928	..	38,955	..	98,833	..	39,335	..	18,016,191
1929	..	43,926	..	102,124	..	34,523	..	20,821,284
1930	..	38,189	..	90,630	..	35,234	..	20,750,337
Total	..	154,728		390,694		152,733		78,463,562
1931	..	48,138	..	93,865	..	33,466	..	21,142,176
1932	..	51,252	..	45,700	..	29,963	..	23,144,466
1933	..	53,070	..	64,340	..	39,492	..	21,699,017
1934	..	69,843	..	105,469	..	32,336	..	31,417,388
Total	..	222,303	..	309,374		135,257		97,403,047
1935	..	55,468	..	48,761	..	33,217	..	20,855,213
1936	..	34,461	..	51,774	..	30,088	..	16,891,569
1937	..	66,856	..	70,849	..	29,438	..	11,119,209
1938	..	75,396	..	75,184	..	29,692	..	15,955,030
Total	..	232,181		246,568		122,435		64,821,021

The conversion factors used in the articles by Rutherford and Stockdale were :—

1 ton of oil	..	.. 8,125 nuts	(61·5 per cent. oil expression).
1 ton of copra	..	.. 5,000 ,,	(1,250 nuts per candy).
1 ton of desiccated	..	.. 6,900 ,,	(325 lb. DCN per 1,000 nuts).

The present writer has elsewhere (cf. *The Tropical Agriculturist,* 1937, Vol. LXXXIX, p. 222) used slightly different factors :—

1 ton of oil	..	.. 7,619 nuts	(63 per cent. oil expression).
1 ton of copra	..	.. 4,800 ,,	(1,200 nuts per candy).
1 ton of desiccated	..	.. 6,400 ,,	(350 lb. DCN per 1,000 nuts).

but has used the former set in the present survey for the sake of continuity with the earlier articles.

TABLE II.

Statement showing the Annual quantity of Coconuts utilized in the various Products exported from Ceylon

Year.	Oil.	Copra.	Desiccated.	Fresh Nuts.	Total.
1911	205,164,375	205,455,000	100,809,000	15,723,393	527,151,768
1912	163,223,125	153,520,000	95,186,000	16,010,809	427,939,924
1913	222,210,625	279,325,000	104,811,000	16,861,324	623,207,949
1914	197,551,250	352,985,000	107,591,700	11,429,524	669,557,474
Total	788,149,375	991,285,000	408,397,700	60,025,050	2,247,857,115
Average p.a.	197,037,344	247,821,250	102,099,425	15,006,262	561,964,281
1915	203,734,375	302,130,000	120,405,000	5,827,669	632,097,044
1916	131,226,875	327,485,000	105,618,300	4,694,297	569,024,472
1917	176,596,875	269,675,000	93,860,700	5,289,481	545,422,056
1918	214,288,750	318,080,000	70,159,200	6,553,278	609,081,228
Total	725,846,875	1,217,370,000	390,043,200	22,364,725	2,355,624,800
Average p.a.	181,461,719	304,342,500	97,510,800	5,591,181	588,906,200
1919	274,625,000	439,880,000	232,895,700	3,390,710	950,791,410
1920	206,180,000	339,465,000	178,965,000	9,776,479	734,386,779
1921	196,917,500	341,860,000	300,329,400	23,738,542	862,845,442
1922	225,314,375	421,645,000	265,035,900	22,317,747	934,313,022
Total.	903,036,875	1,542,850,000	977,226,300	59,223,478	3,482,336,653
Average p.a.	225,759,219	385,712,500	244,306,575	14,805,869	870,584,163
1923	195,219,375	253,865,000	282,486,000	15,693,670	747,264,045
1924	224,501,875	442,295,000	300,612,300	29,121,041	996,630,216
1925	250,981,250	568,430,000	273,985,200	23,288,786	1,116,685,236
1926	231,749,375	604,850,000	260,254,200	16,951,368	1,113,804,943
Total	902,451,875	1,869,440,000	1,117,337,700	85,054,865	3,974,284,440
Average p.a.	225,612,969	467,360,000	279,334,425	21,263,716	993,571,110
1927	273,471,250	495,535,000	301,122,900	18,875,750	1,089,004,900
1928	316,509,375	494,165,000	271,411,500	18,016,191	1,100,192,066
1929	356,898,750	510,620,000	238,208,700	20,821,284	1,126,548,734
1930	310,285,625	453,150,000	243,114,600	20,750,337	1,027,300,562
Total	1,257,165,000	1,953,470,000	1,053,857,700	78,463,562	4,342,956,262
Average p.a.	314,291,250	488,367,500	263,464,425	19,615,890	1,085,739,065
1931	391,283,750	469,325,000	230,915,400	21,142,176	1,112,666,326
1932	416,422,500	228,500,000	206,744,700	23,144,466	874,811,666
1933	431,193,750	321,700,000	272,494,800	21,699,017	1,047,087,567
1934	567,474,375	527,345,000	223,118,400	31,417,388	1,349,355,163
Total	1,806,374,375	1,546,870,000	933,273,300	97,403,047	4,383,920,722
Average p.a.	451,593,594	386,717,500	233,318,325	24,350,762	1,095,980,181
1935	450,677,500	243,805,000	229,197,300	20,855,213	944,535,013
1936	279,99[illegible],625	258,870,000	207,607,200	16,891,569	763,364,394
1937	543,205,000	354,245,000	203,122,200	11,119,209	1,111,691,409
1938	612,592,500	375,920,000	204,874,800	15,955,030	1,209,342,330
Total	1,886,470,625	1,232,840,000	844,801,500	64,821,021	4,028,933,146
Average p.a.	471,617,656	308,210,000	211,200,375	16,205,255	1,007,233,286

An inspection of the figures shows that the average exports for the four-yearly periods dealt with showed a continued increase after 1926 (which was the last year of Stockdale's survey) up to the period 1931–1934, when average figures were almost double those of the pre-war four years. This is brought out clearly by expressing the average exports in each period as percentages of those for 1911–1914.

Years.	Total exports as nuts.	
1911–1914	2,247,856,125	100
1915–1918	2,355,624,800	105
1919–1922	3,482,336,653	155
1923–1926	3,971,284,440	177
1927–1930	4,342,956,262	193
1931–1934	4,383,920,722	195
1935–1938	4,028,933,146	179

The last four years have, however, shown a definite decline, amounting to almost 90 million nuts per annum.

Local consumption.—The present writer has elsewhere (*loc. cit.*) discussed the probable extent of local consumption and concluded that Rutherford's estimate of 130–145 per head of the population per annum was, as far as could be judged, a reasonable one. This estimate has received a certain amount of confirmation from a quite independent source. Dr. Das Gupta in a report on the economic survey of five villages in Chilaw District, *Bulletin No. 7 of the Ministry of Labour, Industry and Commerce* (1937), page 29, gave a figure of 10·65 nuts per head per mensem as the average consumption found in his survey. This is remarkably near the figure of 130 per head estimated by quite other lines of argument.

The population of Ceylon at the 1911 Census was 4,106,350; on December 31, 1938, the population was estimated at 5,864,000 (*Ceylon Government Gazette*, April 13, 1939, No. 8,445, p. 540). The local consumption at 130 nuts a head per annum would thus have increased from 533,825,500 to 762,320,000 nuts during the 28 years under review.

Taking this basis for estimating local consumption of nuts—*viz.*, estimated population × 130—the following table is arrived at for estimated total average production :—

TABLE III.

Estimated Total Production of Nuts in Ceylon

Years.	Average Population (Approx.)	Local Consumption.	Percentage of Total.	Average Exports as nuts.	Percentage of Total.	Total Production (Nuts.)
1911–14	4,166,000	541,580,000	49·1	561,964,281	50·9	1,103,544,281
1915–18	4,326,000	562,380,000	48·8	588,906,200	51·2	1,151,286,200
1919–22	4,500,000	585,000,000	40·2	870,584,163	59·8	1,455,584,163
1923–26	4,720,000	613,600,000	38·2	993,571,110	61·8	1,607,171,110
1927–30	5,045,000	655,850,000	37·7	1,085,739,065	62·3	1,741,589,065
1931–34	5,472,000	711,360,000	39·4	1,095,980,181	60·6	1,807,340,181
1935–38	5,700,000	741,000,000	42·4	1,007,233,286	57·6	1,748,233,286

Against the decline of exports between the periods 1931–1934 and 1935–1938, of about 90 million nuts, there can be set off on the above basis an increase in local consumption of some 30 million nuts, leaving a net decrease in production per annum of 60 million nuts.

It is of interest to note that, on such estimates as the foregoing, local consumption from 1919 to 1934 remained pretty constantly round about 40 per cent. of the total production. For the next few years, unless estates and small holdings are increasingly taken in hand for replanting and cultivation, production will show a progressive decline. Increase in population will meanwhile increase local consumption. Further, efforts are contemplated to aim at increasing consumption in those districts where the coconut is not an important article of diet. The exports of coconut products may therefore be expected to decline still further.

TABLE IV.

Percentage Distribution of Exports

Years.	Oil.	Copra.	Desiccated.	Nuts.	Total. Per Cent.
1911–1914	35·1	44·1	18·2	2·6	100·0
1915–1918	30·8	51·7	16·6	0·9	,,
1919–1922	25·9	44·3	28·1	1·7	,,
1923–1926	22·7	47·0	28·1	2·1	,,
1927–1930	28·9	45·0	24·3	1·8	,,
1931–1934	41·2	35·3	21·3	2·2	,,
1935–1938	46·8	30·6	21·0	1·0	,,

Table IV. shows what percentages of the exports were represented in the different periods by the four main export commodities. Desiccated coconut, which from 1919–1926 formed 28·1 per cent. of the exports, commenced to decline with the loss of the U. S. Market. The most significant aspect of this table is the rise in the proportion of coconut oil. Leaving on one side desiccated coconut and fresh nuts, it will be seen that, from 1931–1938 inclusive, approximately 57 per cent. of all copra sold in Ceylon has been milled for oil, and it is as well to notice this indication of the importance of the local crushing industry.

Value of exports.—It will be of interest to conclude this article with a survey of values of exports over similar periods, as was done by Stockdale.

TABLE Va.

Values of Exports in Rupees

Year.	Oil.	Copra.	Desiccated.	Fresh nuts.	Total.
1927	16,567,551	31,844,823	20,481,761	1,515,087	70,409,222
1928	19,265,529	31,801,635	19,840,117	1,424,287	72,331,568
1929	18,024,359	26,315,987	11,875,780	1,281,910	57,498,036
1930	13,189,849	18,028,725	10,035,931	972,115	42,226,620
	67,047,288	107,991,170	62,233,589	5,193,399	242,465,446
	16,761,822	26,997,792	15,558,397	1,298,350	60,616,361

TABLE VA.—*contd.*

Values of Exports in Rupees—*contd.*

Year.	Oil.	Copra	Desiccated.	Fresh Nuts.	Total.
1931	.. 12,130,476..	12,715,258..	6,832,308..	759,461..	32,437,503
1932	.. 14,475,109..	8,284,294..	7,150,151..	1,135,545..	31,045,099
1933	.. 10,800,402..	6,828,435..	6,746,623..	577,915..	24,953,375
1934	.. 10,460,714..	9,244,405..	4,134,745..	608,392..	24,448,256
	47,866,701	37,072,392	24,863,827	3,081,313	112,884,233
	11,966,675	9,268,098	6,215,957	770,328	28,221,058
1935	.. 13,646,579..	7,818,398..	7,307,560	1,111,077 ..	29,883,614
1936	.. 9,948,909..	10,077,212..	7,041,825..	916,054..	27,984,000
1937	.. 20,060,615..	12,510,641..	6,780,157..	621,379..	39,972,792
1938	.. 14,057,087..	8,782,825..	4,399,494..	634,765..	27,874,171
	57,713,190	39,189,076	25,529,036	3,283,275	125,714,577
	14,428,297	9,797,269	6,382,259	820,819	31,428,644

TABLE VB.

Years.	Nuts.	Rs.	Average per 1,000 nuts.	Percentage of 1911 14 average.
1911–1914	.. 561,964,281	.. 38,860,021	.. 69·15	.. 100
1915–1918	.. 588,906,200	.. 36,673,670	.. 62·27	.. 90
1919–1922	.. 870,584,163	.. 71,208,212	.. 81·79	.. 118
1923–1926	.. 993,571,110	.. 69,304,375	.. 69·75	.. 101
1927–1930	.. 1,085,739,065	.. 60,616,361	.. 55·83	.. 81
1931–1934	.. 1,095,980,181	.. 28,221,058	.. 25·75	.. 37
1935–1938	.. 1,007,233,286	.. 31,428,644	.. 31·20	.. 45

These figures hardly need comment. The average export price of produce calculated for comparative purposes per 1,000 nuts was Rs. 28·36 during the eight years 1931–1938 inclusive, or only 41 per cent. of the 1911–1914 average price. At the same time costs of production can be and have been reduced by economical working to a level considerably below this figure, and properties can still be maintained in reasonable cultivation at this price level.

VEGETATION, CLIMATE, AND SOIL AND WATER CONSERVATION

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THE subject of afforesting areas of low rainfall is very closely connected with the problem of soil and water conservation. The once popular belief that forests affected the climate of a country generally, has not yet proved to be strictly correct. The change from fertility to aridity which has occurred in certain areas has been due chiefly to deforestation ; but this, in any cases known, has not greatly affected the climate either as regards temperature or rainfall.

In the main, it is not so much a question of vegetation affecting climate as climate affecting vegetation, and the chief climatic factor in this connexion is undoubtedly rainfall. Climate, or the average state of the weather, is chiefly determined by temperature, topography, and rainfall. Temperature is governed mainly by altitude and latitude : topography by the forces of erosion, geologic and induced : and rainfall by changes in the temperature and humidity of the air. The vegetation of any area is mainly determined by rainfall, and this explains why the characteristic natural vegetation, in both tropical and temperate regions, with an abundant rainfall is forest, with a moderate rainfall is grass savannah or steppe, and why there is no vegetation in desert areas.

To attempt to create forests in the unirrigated areas of Ceylon which have only a moderate rainfall would be working against nature, with little or no likelihood of success ; while to irrigate and afforest such areas would not appear to be an economic proposition.

It is certainly true that forests occasionally do increase rainfall to a slight extent, particularly in the neighbourhood of the trees, but they cannot alter its seasonal periodicity. In comparison with unforested land, however, forests tend to conserve rain water and to modify extremes of both moisture and temperature. The quantity of surface run-off water is reduced and its rate of flow retarded when a litter of fallen leaves covers the surface of the soil, which is thus kept in a moister and more absorptive condition.

In connexion with forest vegetation, the factor of plant transpiration has also to be considered. It is well known that the transpiration of water by plants is much greater in dry, hot areas than in moister and cooler ones, but to what extent and to what elevations this applies has never been very clearly defined. In 1937, some investigations were recorded by Coster on the transpiration of different types of vegetation in Java. The results of these investigations indicate that, at altitudes of over 3,000 feet receiving more than 140 inches of rain in the year, 60 per cent. or more of the rainfall becomes surface run-off and nearly 25 per cent. is used up in transpiration. At lower elevations where rainfall is less and transpiration is greater, many types of vegetation use up in transpiration all the water which percolates into the soil, even during the wet season. In view of this fact it is concluded that the afforestation of the plains is inexpedient in cases where stream-flow and water conservation are desirable. Low-growing vegetation, however, can still provide a necessary protection to the soil from erosion and can materially assist in reducing the percentage of surface run-off water, but the types selected should have low transpirational tendencies. Short grass is considered to be one of the types which best fulfils both these requirements, and it is now well established that a good grass cover is the most effective natural means of controlling surface run-off and preventing erosion. In up-country areas where evaporation from tropical vegetation is much less, and where an abundant undergrowth provides the best possible conditions for the prevention of erosion and for the percolation of water into the soil, water conservation and control of soil erosion are best secured under a mixed forest.

Ceylon happens to be situated in that part of the world in which a tropical monsoon climate prevails. The monsoon itself is not a rain but a wind, which characteristically blows one way during one part of the year and the opposite way during another. In between these two main seasons are periods of change-over, when unsettled weather prevails. The winds during these two monsoon periods often bring with them cool, moisture-laden air which, according to the greater or lesser amounts of heated-up air or land surface that they encounter or pass over, precipitate less or more of this moisture in the form of rain. Thus, the south-west of Ceylon generally receives more rain during the south-west monsoon than it does during the north-east monsoon, and the north-east of Ceylon usually receives more rain during the north-east monsoon than it does during the south-west. We cannot, however, control or regulate these natural phenomena, so we cannot in any material way affect either the amount or duration of the rainfall. Areas which receive an excess of rain, over and above the actual

requirements of the vegetation they support, even if this rain falls only during a few months in the year, have to provide for the removal of this excess by drainage, natural or artificial. On the other hand, areas subject to a deficiency of rainfall have to meet the requirements of such vegetation as it is desired to establish by means of irrigation.

Now it happens to be one of the unchangeable characteristics of those tropical monsoon climate areas, which normally receive only a moderate rainfall, that the monsoon rains, as during the 1938-39 north-east season, occasionally fall below the limit essential for successful cultivation; thus the importance of irrigation, and of water storage and conservation, in these areas.

In dry areas, such as the Jaffna and Hambantota Districts, in which the amount and distribution of the rainfall is only sufficient to maintain a very meagre cover of vegetation, soil erosion is liable to be more widespread since less of the rainfall percolates into the soil and a greater amount becomes surface run-off water. It is in such areas, therefore, that there is a greater need for the conservation of as much of this surface run-off as possible. The afforestation of such areas, even if feasible, is unlikely adequately to effect this, since the greater part of the moisture absorbed by the soil will be lost to wells and springs through transpiration.

The one method of reducing soil erosion and of conserving surface run-off water in the drier parts of Ceylon would appear to lie in the establishment and maintenance of low-growing vegetation, such as drought-resistant grasses and ground-cover plants. These would reduce the rate of movement of surface run-off water, giving it more time to sink into the soil, and increase the absorptive capacity of the surface soil by keeping it in a moister and more open condition.

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FURTHER MANURIAL AND CULTURAL EXPERIMENTS ON CHILLIES.

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IN the October, 1938, issue of *The Tropical Agriculturist* (1) an account was given of manurial experiments on chillies conducted at the Vavuniya and Anuradhapura Experiment Stations during the 1937 *maha* season. It was observed that very appreciable yield increases resulted from the use of nitrogenous fertilizers, and that the addition of phosphorus and potassium to the latter was not productive of higher yields. Farmyard manure applied at the rate of 3 tons per acre was effective in increasing the crop significantly at Vavuniya but not at Anuradhapura. This was attributed to the fact that at the latter centre the experimental area had been penned with cattle immediately prior to the trial. In extension of these trials, an experiment was carried out at the Experiment Station, Jaffna, during *yala* 1938, (i.) to compare the effects of a single and double dressing of nitrate of soda on the crop; (ii.) to determine the response to farmyard manure alone and in combination with artificial fertilizers; and (iii.) to ascertain which of two methods of picking the crop was preferable from the standpoint of yield.

DESIGN OF THE EXPERIMENT

The experiment, consisting of twelve treatments, combinations of the three sets of factors enumerated above, was laid down in six randomized blocks of six plots each. The interactions between farmyard manure and method of picking, and between nitrogen, farmyard manure, and method of picking, were partially confounded with block differences. The design was that recommended by Yates (2) in his " Design and Analysis of Factorial Experiments ".

Each plot was 39 ft. by 21 ft. in external dimensions. After leaving a border row, the net area of a harvested plot was

30 ft. by 12 ft., containing five rows of eleven hills each spaced 3 ft. apart between and within rows. Drains separated the plots and blocks from one another.

The factors tested out were the following :—

Nitrogenous fertilizers :	(i.)	No nitrogen
	(ii.)	Single nitrogen (N) : nitrate of soda in one dressing of $2\frac{1}{2}$ lb. per plot (20 lb. nitrogen per acre)
	(iii.)	Double nitrogen (2N) : nitrate of soda in two dressings of $2\frac{1}{2}$ lb. per plot each (40 lb. nitrogen per acre)
Farmyard manure :	(i.)	No farmyard manure
	(ii.)	Farmyard manure (F) at $1\frac{1}{2}$ cwt. per plot or 4 tons per acre
Method of picking :	(i.)	Pods picked red throughout (R)
	(ii.)	Normal method pods picked green at first picking ; all subsequent pickings red

EXPERIMENTAL DETAILS

The experimental details were furnished in a paper by Paul and Fernando (3) on the effect of manuring on the incidence of chilli leaf curl and need not be repeated here. It would suffice to state that the farmyard manure was ploughed in just prior to planting and the artificial fertilizer applied in the rows in two dressings, the first about three weeks after harvesting and the second a month after the first. Two seedlings of Tuticorin chillies were planted per hill. Observations were kept on the incidence of diseases and pests, the times of flowering and fruiting, dates of picking, &c. Leaf-curl of the type described in the paper referred to was markedly prevalent in all the plots, no less than 87 per cent. of the plants being affected with the disease at one stage. Neither farmyard manure nor nitrate of soda had any effect on the resistance or susceptibility of chillies to the disease. Many plants were also affected by *Sclerotium rolfsii*, the black stem disease. At each picking, a representative sample of fresh chillies of each of the different treatments was weighed and dried, and the percentage outturn of dry chillies determined. The average weight per pod and the number of chillies per pound were also ascertained at the same time. The rainfall data were presented in the paper already referred to (3). The precipitation having been insufficient during the months of May, June and July, irrigation was necessary on eighteen occasions.

RESULTS

The results are presented in a series of seven tables which give the actual or average yields of crop in lb. per plot, cwt. per acre or percentages. In table I. the actual yields of crop from the different plots are shown; in table II. is set out the analysis of variance of the data after the necessary corrections have been effected; table III. gives the yields in cwt. per acre for the different treatments and table IV. shows the average effects of the different treatments. In table V. the percentages of the total yields obtained at the different pickings and up to each picking are indicated for certain of the treatments. Tables VI. and VII. give the average weights per pod in grains and the mean number of pods per pound for the varying treatments and for the different pickings.

TABLE I.

Yields (lb. per plot)

	Blocks					
	Ia	*Ib*	*IIa*	*IIb*	*IIIa*	*IIIb*
	69·1	54·9	50·2	44·4	25·4	14·1
	G2N	RN	RF	GN	GN	GNF
	33·8	42·3	50·7	29·1	21·8	9·2
	R	G	R2NF	RNF	G2NF	GF
	73·8	79·2	64·7	42·3	16·3	7·8
	GF	R2N	GNF	GF	G	R
	83·9	47·7	78·3	41·4	17·5	21·4
	GN	RF	G2N	R2N	RNF	G2N
	82·9	67·2	52·6	54·4	21·7	32·0
	R2NF	GNF	G	G2NF	RF	R2NF
	64·7	74·5	49·3	23·0	24·6	19·0
	RNF	G2NF	RN	R	R2N	RN
Totals ..	408·2	365·7	345·8	234·6	127·3	103·5

Grand Total = 1,585·1
Mean = 44·03

TABLE II.

Analysis of Variance

Treatments

	D. F.	Sum of Squares	Mean Square	F
Nitrogen (N) ..	2	.. 1,834 ·62	.. 917 ·31 ..	**10 ·24**
F. Y. M. (F) ..	1	.. 74 ·25	.. 74 ·25 ..	
Picking red *vs.* green (P) ..	1	.. 441 ·70	.. 441 ·70 ..	**4 ·93**
F × N ..	2	.. 356 ·43	.. 178 ·21 ..	1 ·98
P × N ..	2	.. 145 ·70	.. 72 ·85 ..	
F × P ..	1	.. 8 ·13	.. 8 ·13 ..	
N × F × P ..	2	.. 23 ·35	.. 11 ·67 ..	
	11	2,884 ·18	262 ·20	

	D. F.	Sum of Squares	Mean Square	F.
Blocks ..	5	.. 13,856 ·51	.. 2,771 ·30 ..	
Treatments ..	11	.. 2,884 ·18	.. 262 ·20 ..	**2 ·93**
Error ..	19	.. 1,701 ·95	.. 89 ·58 ..	
	35	18,442 ·64		

F (sig.) for $n_1 = 11, n_2 = 19$, P = ·05 is 2 ·43 and for P = ·01 is 3 ·54.
Treatments are significant to P > ·05.

F (sig.) for $n_1 = 1$, $n_2 = 19$, P = ·05 is 4 ·38, P = ·01 is 8 ·18.

F (sig.) for $n_1 = 2$, $n_2 = 19$, P = ·05 is 3 ·52, P = ·01 is 5 ·93.

Treatments showing F values in bold type are significant.

TABLE III.

Yields in Cwt. per Acre

	No Nitrogen	Single Nitrogen	Double Nitrogen	Average	Corrected: No Farm-yard Manure	Corrected: Farm-yard Manure
Green (G)..	42 ·57 ..	53 ·92 ..	57 ·51 ..	51 ·33 ..	50 ·33 ..	52 ·34
Red (R)..	33 ·16 ..	42 ·21 ..	55 ·94 ..	43 ·77 ..	41 ·68 ..	45 ·86
Average ..	37 ·86	48 ·07	56 ·72	47 ·55	46 ·00	49 ·10

Significant difference for method of picking: P = ·05 is 5 ·04 cwt.; P = ·01 is 6 ·89 cwt.

Significant difference for quantity of nitrogen: P = ·05 is 6 ·17 cwt.; P = ·01 is 8 ·44 cwt.

TABLE IV.

Summary of Effects

	Lb. per plot	Cwt. per acre
Single Nitrogen	**9·45**	**10·21**
Double Nitrogen	**17·47**	**18·86**
Double *v.* Single Nitrogen	**8·01**	**8·65**
Farmyard Manure	2·87	3·10
Picking : Red *v.* Green	**— 7·0**	**—7·56**
Standard Error per plot	9·47	10·2
Significant differences :		
Nitrogen : P = ·05	5·71	6·17
P = ·01	7·81	8·44
Picking : P = ·05	4·67	5·04
P = ·01	6·38	6·89

Figures in bold type indicate significance.

An examination of the data provided by the above tables will indicate that :

(1) Both single and double dressings of nitrate of soda increased yields very significantly. The single dressing gave an average fresh weight increase of 10·2 cwt. per acre or 27 per cent. over the unmanured plot which yielded 37·8 cwt. per acre, while the double dressing recorded an average increase of 18·8 cwt. per acre or 50 per cent. over the control. Reckoned as dry chillies, these increases worked out at 3 and 5·5 cwt. per acre respectively, on an average dry weight outturn of 30 per cent. as determined by experiment. The effect of the second dressing of nitrate of soda was to increase yields by nearly as much as the first. These results are very definitely significant, the odds being over 100 to 1 that they are not due to chance but to the treatment. It is obvious, therefore, that, under the soil and climatic conditions of Jaffna, applications to chillies of nitrate of soda up to 2½ cwt. per acre will be definitely beneficial in respect of yield. The findings of all previous trials in regard to the efficacy of nitrogenous fertilizers for chillies are thereby confirmed. Appreciably higher yield increases would doubtless have been obtained but for the incidence of the leaf-curl and black stem diseases.

(2) In regard to the economic aspect of manuring chillies at Jaffna, reckoning on a market price of Rs. 15 per cwt. of dry chillies, the gross increased returns would be Rs. 45 and Rs. 82 per acre respectively from the single and double nitrogen-

treated plots, as against a corresponding expenditure of Rs. 10 and Rs. 20 per acre on the fertilizer and the same amounts on the extra cost of picking and curing. The increased nett profits per acre as a result of the manuring would therefore vary from Rs. 25 to Rs. 42 per acre. Under more favourable crop conditions, the returns would have been appreciably higher.

(3) Farmyard manure has not, under the conditions of this trial, produced a significant yield increase, when the average yield of plots treated with farmyard manure is compared with that of corresponding plots which did not receive farmyard manure. The individual yield results do, however, strongly suggest that farmyard manure applied alone is beneficial to the crop. It is therefore advised that, particularly on the calcareous loams of the Jaffna Peninsula which are deficient in organic matter, farmyard manure or compost be used as a basal dressing for chillies at a minimum of 2 tons per acre.

(4) The practice of harvesting chillies "green" *i.e.*, at the stage when the pods though mature are of a green colour, at the first picking and "red" at subsequent pickings, is definitely more advantageous than the method of picking chillies "red" throughout. In addition to the fact that the total yield of crop is appreciably increased by the method of "green" picking, the actual increase in this instance being 7·5 cwt. of fresh chillies, there is the advantage that the green chillies can almost invariably be sold at remunerative prices. The outturn by weight of dry chillies has been found by experiment to be 30 per cent. in the case of pods picked "red" and 27·5 per cent. in the case of pods picked "green". On these figures, the minimum increased profit that would result from the adoption of this system of picking would be approximately the price of 2 cwt. of dry chillies or Rs. 30 per acre. The practice is, therefore, strongly to be recommended, particularly where there is a ready market for green chillies.

(5) None of the interactions between the different factors under experiment has proved significant.

(*For Table V. see page 345*).

It will be noted from table V that :

(i.) Though there appears to be a tendency for nitrogen to delay slightly the ripening of the pods, there is no certainty that such is actually the case, especially in view of the reverse result noted previously (1).

(ii.) There is a steady fall in yield of crop from the third pick onwards. About 95 per cent. of the total crop is obtained in six pickings, and 50 per cent. from the first three picks.

TABLE V.

	Per cent. of total at different pickings							Total per cent. up to particular picking						
	1st	2nd	3rd	4th	5th	6th	7th	1st	2nd	3rd	4th	5th	6th	7th
1. 1st picking green	23·6	6·3	19·6	18·7	18·0	9·3	4·5	23·6	29·9	49·5	68·2	86·2	95·5	100
2. 1st picking green, double nitrogen	17·1	8·1	22·0	14·7	19·9	12·0	6·2	17·1	25·2	47·2	61·9	81·8	93·8	100
3. All pickings red	5·9	20·1	24·3	19·5	16·0	7·9	6·3	5·9	26·0	50·3	69·8	85·8	93·7	100
4. All pickings red, double nitrogen	3·8	16·0	24·4	22·2	17·9	11·2	4·5	3·8	19·8	44·2	66·4	84·3	95·5	100

TABLE VI.

Manurial treatment	Mean weights of pods in grains			Mean numbers of pods per pound		
	Green	Red	Average	Green	Red	Average
1. Control	6·8	7·0	6·9	1,206	1,199	1,202
2. Single nitrogen	6·5	7·9	7·2	1,249	1,130	1,190
3. ,, †F.Y.M.	7·0	7·3	7·15	1,170	1,110	1,140
4. Double nitrogen	6·9	7·2	7·05	1,197	1,133	1,165
5. ,, †F.Y.M.	7·2	7·2	7·2	1,222	1,127	1,174
6. F. Y. M.	6·4	7·0	6·7	1,173	1,157	1,165
Average	6·80	7·27	7·03	1,203	1,143	1,173

TABLE VII.

	Picking						
	1st	2nd	3rd	4th	5th	6th	7th
Mean weights of pods in grains—							
Red	8·4	8·6	7·9	7·7	7·3	6·4	4·6
Green	—	7·3	7·8	8·0	7·6	5·9	4·2
Mean numbers of pods per pound—							
Red	888	864	952	1,025	1,102	1,323	1,844
Green	—	1,025	960	1,012	1,090	1,309	1,821

Tables VI. and VII. summarize the results of determinations of the average weights of pods and numbers of pods per lb. made on representative samples of dry chillies at each picking. It will be observed that :

(1) The average weight per pod of chillies picked "red" from the start is very slightly higher than that of chillies picked "green" at first, but the difference may not be significant. As would be expected, the reverse holds in respect of the number of dry pods per lb. The latter varies from 1,110 to 1,250.

(2) There are no appreciable variations in average weights of pods from differently manured plots.

(3) There is, in general, a decrease in the average weight of pod and consequently an increase in the average number of pods per lb. with advancing picking after the first two picks. The number of pods per lb. rises from 888 in the first picking to 1,844 in the last picking in the case of chillies picked "red" throughout.

SUMMARY

A combined manurial and cultural trial conducted at the Jaffna Experiment Station in the *yala* 1938 season led to the following important conclusions :—

(1) Both single and double dressings of nitrate of soda result in very significant yield increases over the control; the double dressing is definitely superior to the single dressing.

(2) The enhanced profits from manuring chillies, on the data obtained in this experiment, vary from Rs. 25 to Rs. 42 per acre, assuming the price of dry chillies to be Rs. 15 per cwt.

(3) Harvesting chillies "green" at the first picking, and ripe or "red" at subsequent pickings, is very definitely superior in respect of crop yield to picking chillies "red" throughout. An increased fresh weight of 7·5 cwt. per acre of chillies has thus been obtained.

(4) Farmyard manure has not, under the conditions of this trial, produced a significant average yield increase. There is, however, a strong suggestion that used alone farmyard manure is beneficial, and its application, even in relatively small quantities as a basal dressing for chillies under Jaffna conditions, is advocated.

(5) The average outturn by weight of dry chillies on fresh chillies is 30 per cent. when picked "red", and 27·5 per cent. when picked "green".

(6) There is a marked decline in average weight of pod as picking advances, and a steady fall in yield of crop from the third picking onwards.

(7) There is no appreciable variation in the average weights of pods from differently manured plots.

ACKNOWLEDGEMENTS

It is with much pleasure that we acknowledge the valuable assistance rendered us in this trial by Mr. S. Balasingham, Manager, Experiment Station, Jaffna, who has been mainly responsible for making the numerous records involved.

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DEPARTMENTAL NOTE

MULTIPLE BIRTHS IN CATTLE

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THE birth of more than one calf to a cow at a birth is so unusual in Ceylon as to be worthy of record when it occurs.

Cow No. 30 at the Government Dairy, Colombo, gave birth to three bull calves on April 3, 1939. She is a three-quarter-bred Ayrshire Scind aged 4 years and 2 months. She was due to calve on April 8. Unfortunately labour occurred a little prematurely on April 3. She had a difficult calving and required assistance. All three calves were born dead. They were all bulls. Their approximate weights were 35 lb., 30 lb., and 20 lb. The normal weight of a single calf at full term for this breed of cow is between 50 and 60 lb. so that they were all below normal although the total weight *i.e.*, 85 lb. was considerably above normal.

As a rule about 100 calves are born each year at the Government Dairy and so far as records show triplets have never been born before at this Dairy. Twins have been very rare but have occurred on several occasions. Curiously enough the first occasion on which twins have been born at the Peradeniya Farm School Dairy since its inception was in February of this year.

It is of interest to note that when twin calves are born, if they are both of the same sex, either two bulls or two heifers, they are normal; when one is a bull and the other a heifer the bull calf is normal but in about 8 cases out of 9 the heifer is what is called a "freemartin" and is sterile and useless for breeding.

This curious fact is because when twin calves are developing in the uterus of the cow there seems to be a very marked tendency for fusion of the two placental membranes to occur. As a result of the fusion of the placental membranes blood circulates in common through the blood vessels of both calves. Hormones from the developing sex glands of the bull calf gain entrance to the circulating blood and can be carried with the blood to the twin heifer calf. The male sex hormones circulating in the blood

appear to exercise an inhibitory effect on the developing female sex glands of the twin heifer with the result that their development is permanently checked and the ovaries and connected sex organs have their growth arrested at a very early stage and remain infantile throughout the freemartin's life. As a consequence the freemartin is incapable of breeding and is of no value save for the butcher.

SEASONAL PLANTING NOTES

CALENDAR OF WORK FOR JUNE

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JUNE is usually a busy month for the gardener both in the flower garden, plant house, and vegetable garden.

In the south-western areas, the monsoon rains will have arrived and all grounds still lying fallow should be dug and manured to allow the rains to soak in and nitrify the soil in preparation for the full planting period. All transplanting of shrubs and perennials should be completed this month, and the more tender annuals can be planted out towards the end of the month. The latter will include asters, zinnias, *Phlox Drummondii*, anthusa, marigold, arctotis, hollyhock, petunia, salvia seedlings and the like.

In planting such annuals, the surface of the bed or border should be cleared of all stones leaving as fine a soil tilth as possible. The removal of seedlings from the boxes to beds should be done very carefully and each seedling taken out with a small ball of earth attached. Much harm may be done in neglecting this important point, particularly with zinnias which are prone to wilt very badly if the young rootlets are stripped of soil or damaged. Watering of the seedling boxes overnight allows the seedling to be removed to best advantage the next morning.

Renovating of lawns, if not yet done, should be completed this month and the fernery or rockery should be overhauled, forked up, and a dressing of leaf-mould dug in. Varieties of indigenous ferns from the jungle should be obtained and all gaps filled in.

Cuttings of plant material for beds and borders inserted in nurseries last month, or early this month, should be watched: and towards the end of the month the overhead shade could be entirely removed. Certain trees, shrubs and climbers, notably the amherstia, ixoras, some bougainvilleas and *Marchiel Neil* roses are propagated mainly by gootees. All such work, if not already done, should be put in hand at once as the rains and

consequent humid atmosphere of the early part of the monsoon ensure rapid rooting as compared to later in the season when hand watering has to be employed.

At Peradeniya Gardens the actual work in hand this month includes planting of ribbon borders of coleus, alternanthera and caladiums and planting out of annuals enumerated above in beds, renovation of lawns, potting of orchids, refilling of all gaps in herbaceous borders, potting of glass-house and green-house plants, and potting of nursery stocks.

Towards the end of the month, further sowings or plantings of vegetables can be made including beans, cauliflower, carrots, kohl-rabi, lettuce, sweet potato, turnip, artichoke and onions.

Up-country, owing to the strong winds experienced during the south-west monsoon, staking of border plants is an important item. The proper season for a show of annuals is January–April, but further sowings can now be made for the planting out of quick-growing varieties in August. Dahlias, and especially tree dahlias, do well at higher elevations and if planted now a very fine show can be made extending into October and November. Dahlias are raised by seed, by tuber or by cuttings and for this time of year plants are attained more quickly if raised from cuttings.

Roses are, naturally, best grown in up-country districts and well-grown plants can produce really fine flowers. They thrive best in a well-drained position with soil of a fairly heavy nature with good humus content. They profit by regular manuring if the manure is given in small doses at frequent intervals. Liquid manure is beneficial also. Imported plants from Australia arrive each year during June and July and if planted in a well-prepared hole in the open away from neighbouring tree roots, good results can be expected for two or three years, after which the rose bush in the tropics degenerates rapidly. This is due chiefly to the plant being grafted on a rootstock unsuited to our conditions though very suitable to those of Australia. The latter country has a winter whilst here we lack this resting season for the plant.

It is wise, therefore, whilst the plant is still in its full vigour to raise fresh stocks by means of cuttings called "own-root plants". It is found that own-root plants thrive well under local conditions, especially up-country, and degeneration such as occurs in the budded plant does not occur to the same degree on own-roots. June is also a very suitable month in which to strike rose cuttings, and well-ripened roots should be selected with, if possible, a portion of the older wood called the "heel" and inserted in prepared beds under shady conditions. The bed should contain a liberal amount of river-sand as this acts as a

very helpful rooting medium. The cuttings should have formed sufficient roots to be planted out in the October-November season.

Plant up all vacant corners, banks, &c. and insert fresh stocks of cuttings in boxes, under cover of such useful flowering plants as verbenas and petunias. This is also a good time to prune back shrubberies and generally to tidy up garden surroundings. Sowings of the hardier vegetables should be persevered with but peas, beans, and other more tender types should be left till August when the monsoon will have almost exhausted itself.

This month is the month of mangoes. As far as information goes, crops are below the average ; nevertheless the usual glut can be expected. Though normally the standard of the majority of Ceylon mangoes is low, there are here and there trees of outstanding merit that produce fruits to rival the best Indian fruits. These can generally be traced back to imports obtained by the late Ceylon Agricultural Society or to the Department Seed Store, now defunct. Grafted plants are from such trees and this is a good time in the south-west monsoon areas to plant such fruit trees.

It is very little more costly to grow a grafted plant of known parentage than an unknown seedling and future fruit growers in orchard or compound are advised to put in only the best available varieties.

SELECTED ARTICLES

THE CITRUS INDUSTRY OF AMERICA*

IN the month of October, 1935, I left Australia for the United States of America, and disembarked at San Francisco on November 4. The object of my visit was to study first-hand citrus methods and problems in that country, particularly in regard to cultural, organization, packing, transport and marketing. From San Francisco I journeyed south to Los Angeles, which city is the centre of the enormous producing district of Southern California. Thence I went to Riverside, sixty miles east of Los Angeles, which I established as my centre.

Before reaching America it was my intention to visit the other large citrus producing States, namely, Arizona, Texas, and Florida. This idea was subsequently abandoned, as in the limited time I had at my disposal and by the adoption of that schedule, I would no more than gain a cursory survey of the industry. As the climate, as well as the cultural and irrigation practices and problems of Southern California appeared to be somewhat similar to those obtaining in South Australian citrus districts, I decided to devote the whole of my investigation to that area.

Being under the impression that the harvesting of Washington Navel oranges in California commenced in November, my visit was timed accordingly. This however, proved not to be the case, and harvesting does not seriously commence till early January. At the time of my arrival the Valencia orange crop was virtually finished.

In this report I propose confining my remarks to Southern California.

All values herein are given in sterling.

Southern California is divided from the Mojave Desert, lying to the east, by the San Bernardino range of mountains, and the citrus is grown in long fertile valleys running towards the Pacific coast. There is no native tree growth either on the mountains, or in the valleys, but millions of imported trees, principally the Tasmanian Blue Gum, the Brazilian Pepper tree, Pines, and Palms, have been planted, and these have vastly improved the appearance and commercial value of the countryside.

The orange trees are planted right up to the foothills, the peaks of which are often snow-capped. The climate is hot in summer with occasional heat waves, and mild in winter, and is subject to heavy frosts. At one time Southern California was largely planted with deciduous trees and vines ; but in the course of time these have given way to citrus and walnuts.

It has been found by experience over a number of years that certain districts and soils prove more suitable to certain varieties of citrus ; for instance,

* *Department of Agriculture, South Australia, Bulletin* No. 316.

Riverside is more particularly suited to the Washington Navel orange. This variety is mainly confined to Riverside, San Bernardino, Los Angeles, and Tulare counties.

Values of oranges groves range from £200 per acre for the poorer types to £400 for the better. But I doubt if one would find sellers of the latter. Prior to the depression, values were much higher, and many properties changed hands at £1,000 per acre. I came in contact with land in the Upland district which was being prepared for lemon growing. The virgin land, which was covered with small bushes and small to huge granite boulders, cost £100 per acre. This was costing £200 to clear, and then the land had to be planted and maintained for several years before the trees came into profitable production. This class of soil is, however, very rich, and ideal lemon country.

The American crop of citrus was a record in 1935, and I understand that the output was 30 per cent. in excess of any previous crop. Thousands of acres which were planted just prior to the depression are now coming into production, and this fact has a bearing on the present huge out-turn.

I saw one of the two parent Washington Navel orange trees. This was introduced into California by Mrs. Eliza Tibbetts in 1873 from Bahia, Brazil. It is quite a small tree, is still bearing fruit, and is planted in Magnolia Avenue, Riverside. These two trees really laid the foundation of the Washington Navel orange the world over.

One of the outstanding features I encountered was that the grower is a grower only, unless he is outside the co-operative organizations. He does not even harvest the fruit, and in many instances leaves fumigation and pruning in other hands. Where possible this policy should be adopted in Australia.

Grapefruit is giving the Americans much thought to-day. They are already over-producing, and there are thousands of acres yet to come into bearing. The several States are much concerned as to how they are going to handle the position when the new areas reach production, but they are confident that with extensive advertising, and propaganda, and the possibility of increased consumption, the future disposal of the fruit at remunerative prices may not present as many difficulties as now appear.

Since December, 1933, a marketing agreement and licence, under the Federal Agricultural Adjustment Act, has been operating for oranges and grapefruit in California and Arizona. This seeks to increase returns to growers by regulating the flow of fruit despatched to market. The scheme was requested by the industry, to which it has given material benefits. The agreement was recently extended for a further 12 months.

THE COMMERCIAL CITRUS GROVE

Southern California is planted mostly with citrus and walnuts, the former largely predominating. The groves are set out very regularly, and everything connected with the properties is neat and orderly. The residences are substantial, mostly two stories, and surrounded with attractive flower gardens, lawns, shrubs, and ornamental trees. Fences are not in evidence, and all properties are open to the road. The pride taken by " Sunkist " growers,

that is, those operating through the Californian Fruit Growers Exchange, is indicated by the fact that every orchard bears a neat enamelled sign bearing the name of the grower and the words " Sunkist Grower ".

The average property contains from 10 to 12 acres, which is all planted with citrus. There are, however, many large properties, some comprising 700 to 1,000 acres, and even larger. These are generally held by corporations.

Breakwinds are used extensively, and it is generally agreed that each 10 acres should be so protected. The Tasmanian Blue Gum is used extensively for this purpose, and has proved most effective.

The average quantity of Washington Navel oranges produced in California during the five-year period 1927–31, was 3½ bushels per tree. A well cared for orchard produces 4 to 5 bushels, and I came in contact with many groves, including large acreages, averaging 10 to 12 bushels per tree. Our standard packed bushel case contains about the weight as the loose fruit contained in their field picking box.

CENTRAL CALIFORNIA

This is a large citrus area situated in Tulare county, some 250 miles north of Los Angeles, and 50 miles south-east of Fresno, and embraces the districts of Tulare, Lindsay, Porterville, &c. Its climate and cultural and irrigation practices are somewhat similar to those obtaining in Southern California; but the product is marketed a little earlier. The fruit is harvested as soon as it is tinged with colour, and then treated with ethylene gas in order to colour the rind thoroughly. All fruit must, however, pass the necessary maturity standard before accepted by the packing houses. This centre is subject to very early and heavy frosts. Otherwise my remarks on Southern California apply generally to this district.

GENERAL APPEARANCE OF TREES AND QUALITY OF PRODUCT

On the whole, except the damage occasioned by the hot winds in October last as mentioned elsewhere, the trees were in excellent heart, and the older plantations (50 years) were certainly in their prime and in full vigour. There is little evidence of off-type fruit. Undoubtedly commercial competitive conditions have forced the elimination of this class of fruit from the market.

The fruit is of very fine even type, with a thin glove-like skin appearance, is full flavoured, juicy, and comparatively free of rag. The freedom of blemishes on the rind was most noticeable ; this is due to windbreaks, treatment against thrips and other pests, and the absence of deadwood. The average yield of high grade fruit similar to Sunkist grade, and having a maximum skin blemish of three per cent., is 74 per cent. of production. If a grower produces under 70 per cent. of this grade he is not considered a successful grower. The better types of orchards produce as high as 90 per cent. I estimate our average of this grade in South Australia to approximate 20 per cent.

ROOTSTOCKS, BUDS, PLANTINGS, &c.

Highly specialized citrus nurseries propagate the young trees for the orchard, and only well-grown rootstocks and selected buds are used. Up till 10 years ago the sour orange stock was in general use ; to-day the tendency is towards

the sweet orange stock, and it is stated that present plantings comprise about 50 per cent. each sour and sweet stocks. The rough lemon or citronella stock is unknown. The principal reason for the production of a uniform line of fruit, consistent in bearing, and freedom from off-type, is because for many years buds from only selected trees have been used. I am of opinion that this factor has a bigger bearing on quality and quantity production than most Australians are aware of.

The main plantings in California comprise Washington Navel and Valencia oranges, grapefruit and lemons. Other varieties are not considered profitable. The Valencia orange is in my opinion, similar to the improved type of Valencia introduced here from Berri and Mildura.

Orange trees, as a rule, are not allowed to branch within 30 in. to 36 in. of the ground. The trees are generally planted at from 70 to 110 to the acre ; but in some of the older orchards there are considerably more per acre, and in many instances the trees are almost interlaced. The general ages of the trees range from 20 to 50 years ; but there are large areas of younger trees.

CLIMATE AND SOIL

The climate of Southern California is of an arid nature and subject to long rainless spells and heat waves. In these respects the conditions are somewhat similar to those in our River Murray belt ; but their humidity is more pronounced than ours, and they are subject to severe frosts which, at times, materially affect the foliage of the trees, as well as rendering large quantities of the fruit unmarketable. In October, 1935, this centre experienced a hot wind blast from the desert, which in places partly, and in other places wholly, defoliated large numbers of trees. The fruit crop was also badly affected, the loss ranging up to over 20 per cent. with an average estimated loss over the whole crop of 12½ per cent.

The soil is largely of a sandy nature, generally of a greyish-brown colour, and much heavier than our Murray Mallee soil. It is of good depth, and has plenty of body ; but I am of the opinion that our soil is capable of equal production if we apply similar cultural practices.

PACKING HOUSES

California is well provided with up-to-date and highly efficient packing houses for the processing and packing of citrus fruits. These are equipped with modern machinery for handling, gassing, washing, processing, packing, and box-making and every effort is made to eliminate hand labour and reduce costs. It requires an annual output of 160,000 to 200,000 boxes to warrant the capital outlay essential to the establishment of a fully equipped installation. The larger houses handle much in excess of these quantities. All operations excepting the sorting, wrapping and the packing of the fruit, are done by machinery and these include box-making, lidding, and strapping the boxes, pasting labels on the boxes, washing, processing and branding the fruit, automatically counting the fruits, grades, &c.

In the majority of the houses all fruit is washed, treated with one of the several chemical preparations for the prevention of decay, waxed and branded. A few houses, however, only dry brush and brand the fruit. Fruit is invariably packed as soon as possible after harvesting.

In every operation the greatest care is exercised to avoid damage of the fruit, and gloves are worn by everyone. Female labour is used almost exclusively in grading, sorting, and packing. The fruit is culled very drastically, and is generally sorted into four grades. The classification used by the Californian Fruit Growers Exchange are :—

First quality, Fancy (Sunkist).
Second quality, Choice (Red Ball).
Third quality, Standard.
Fourth quality, Culls.

The permissible area of skin blemish on Sunkist quality is 3 per cent. of the orange. The first and second qualities are the only ones packed, and these are the only grades despatched outside California ; the third is sold loose in the box and the remainder used for by-products. A large proportion of the crop is used for the manufacture of drinks and by-products.

The only box used is the standard Californian box of two compartments. Our Australian export box is identical with this. These boxes are well ventilated, have a flexible four-piece unitized lid, and are centre strapped. For export purposes the lid is wired at each end. The box is printed with a. advertisement on each side, and attractive labels are used. All branded fruit is wrapped in printed tissue paper wraps. The gross weights of the packed boxes are approximately as follows :—Washington Navel—Domestic 85 lb. export 78 lb. ; Valencia—Domestic 89 lb., export 80 lb. A railcar load consists of 462 boxes of oranges, or 348 boxes of lemons.

A flat charge of one dollar (4*s*. 2*d*.) is made to cover costs of harvesting, transport to packing house, and packing and placing on rail, Exchange, Head Office and District charges. As is usual with co-operative enterprise this charge is subject to rebate to growers at the end of the season; this generally amounts from 10*d*. to 1*s*. Of this charge 7½*d*. is absorbed in harvesting and haulage to the packing house, 2*s*. 1*d*. in packing charges (the made up box costing 7½*d*.), and the balance in Exchange and other charges.

Although many different chemical preparations are used for the prevention of decay, borax appears to be the most common. Since the introduction of these preservatives wastage in fruit between packing house and the consumer has been materially reduced ; but it must be borne in mind that, despite these various treatments, hea. y waste still develops in certain periods of the season.

CULTURAL

Tractors and mules are used for operating orchard implements, the former largely predominating. Heavy type disc and mouldboard ploughs are general, and disc or tyne cultivators for cultivating. The Rotary Hoe is unknown.

Whereas cultivations were formerly deep and frequent, present-day practices are generally for light working, and as infrequently as possible. The periods

between cultivations are governed to a large extent by weed growth, and the necessity of maintaining irrigation furrows in a serviceable condition. As a rule the cultivator is used only after every two or three irrigations. This practice is not adopted by all growers, as some still till the soil frequently. It appeared to me that the absence of the intense cultivation that prevailed formerly, is due in part to economy as a result of the depression, and in part to the now generally accepted principle that the less frequent stirring of the surface soil is beneficial to tilth, root development and moisture penetration.

IRRIGATION

California is in the main an irrigated State, this being wholly so in the citrus areas. In Southern California the average annual rainfall ranges from 10 in. to 15 in. according to the districts. From May to December, 1935, only 2½ in. had been registered. At the time of my visit the plains and mountains were entirely devoid of natural grasses. As a rule, conditions are very dry till about the end of December, after which the winter rains commence. Up till mid-December, there had been eight citrus irrigations, and preparations were being made for another. The average number of citrus irrigations is from seven to eight per annum. Water is applied regularly every 30 days during spring, summer and autumn, with from one or two applications during winter, according to the moisture content of the soil.

Districts vary in the quantity of water used from 25 to 40 acre inches; but the average is about 30 in. applied at the rate of 3½ in. to 4 in. per irrigation. Owing to shortage of water no special or intermediate irrigations are given. The furrow system is almost universal. Furrows are placed as closely together as possible. In some instances a straight course is used; in others furrows are checked or zig-zagged. The water is passed along these furrows as quickly as possible, and water runs are from four to six chains.

Whereas the Australian practice is to place the outside furrow at the fringe of the foliage of the tree, Californians furrow as far under the trees as their implements will permit. Partly for this purpose the foliage is kept well off the ground.

Most of the water is obtained from deep wells by means of pumps. In certain localities there is a definite shortage of irrigation water, and in two districts I noticed that certain sections of areas had been abandoned as a result of water shortage.

Seepage or water-logging of soils is not much in evidence; this is owing to the type of subsoil, and the light irrigations.

Cost of water varies considerably; but taken generally our costs compare favourably with theirs. Water and irrigation labour cost from £3 to £5 per acre per annum. Power for lifting water is very cheap, being quite commonly obtained from engines using natural gas.

FERTILIZERS

Californians are heavy users of fertilizers, more particularly those containing organic matter and nitrogen. It has been proved beyond doubt that barnyard manures, cover crops and nitrogen are the essential ingredients to apply to the

soil for growth and production purposes. Nitrogen is introduced mainly by the use of animal manures, cover crops, fish meal, sulphate of ammonia, nitrate of soda, nitrate of lime, &c. Barnyard and hog manures are applied generally at from five to 10 tons per acre annually, and in many cases heavier. Large quantities of Lucerne and Bean straw are transported long distances and applied heavily. Green humus crops are also grown extensively from Melilotus, Purple Vetch and Mustard. The general practice is to apply about 4 lb. of nitrogen annually, one-half each from organic (preferably cattle manure) and inorganic sources.

The use of phosphate and potash is not much in evidence. It has been proved that these elements are freely distributed throughout Californian soils by nature, and their introduction by artificial means has not produced any definite results, either in tree growth or production.

Cover crops are sown in late summer and early autumn, and disced under in the early spring. Organic manures are applied in the early fall, and nitrogen in early spring.

PESTS AND DISEASES

California is subject to many orchard pests and diseases. Red, black and wax scales are very active, and drastic action is taken against these by means of fumigation and spraying. At times thrips are very prevalent, and usually this pest is treated about three times in its season, either by means of spraying or dusting. The co-operative packing houses do most of the fumigation, &c.

FROST PROTECTION

Much money has been expended in fighting frost. Most orchards are equipped with oil-burning heaters, and these entail a heavy outlay per acre.

Radio messages are broadcast, and growers are warned if there is any likelihood of frost. This gives the grower the opportunity to prepare for his attack, and these heaters are kept burning during the night till all danger is over, usually from four to five hours.

Central California is particularly susceptible to frost, and for this reason all its fruit is harvested early in the season, and before Southern California commences.

HARVESTING

Harvesting is, in my opinion, the most important operation in connection with successful marketing, and is the keynote of the fruit reaching the consumer in sound condition. The grower, excepting those large producers who have their own packing houses, confines his activities to the production of fruit. The harvesting, haulage to packing house, and packing are conducted by the packing houses. These are mostly co-operative, and they send teams of selected men with capable foremen to the orchards for harvesting purposes. The use of picking bags, field picking boxes, fruit clippers and gloves is universal, in fact one would say compulsory.

TRANSPORT

Most of the transport of citrus to other States is by means of the railway, which are operated by private companies. These give the industry excellent

service, and the system is highly organized. Where conditions warrant, such as long distance transport to the East, iced, ventilated vans are used in the summer, and a fast service maintained. In very cold weather oil heaters are used.

The packed boxes of fruit are stacked two high on end in the vans and secured with battens. The type of box used has been designed to fit compactly into the van, which holds 462 boxes.

For conveyance beyond California a flat rail transport rate of 4*s.* 9*d.* per box operates. The boxes are tightly fitted into the vans by means of a machine using an expanding device. The motor track is also used extensively. Fruit for export is, when possible, shipped from Los Angeles and other Pacific ports.

PRUNING

The practice of pruning citrus is universal. On the whole pruning is light ; but the trees are kept fairly well open for ventilation and sunlight purposes, and the foliage is kept well off the ground. Every effort is made to eliminate dead wood, and when possible growers lightly trim out their trees annually. This practice considerably reduces the cost of pruning over, say, a 10-year period. It has been found that heavy pruning of healthy trees is detrimental to subsequent cropping for a year or two.

LABOUR

Large numbers of Mexicans are employed in the orchards and packing houses. Unskilled orchard labourers are paid 12*s.* 6*d.* per day. Packers and sorters, mostly women, are paid at piecework rates. Machinery has replaced labour to a large extent in both orchards and packing houses.

CITRUS EXPERIMENTAL STATION

The Citrus Experimental Station, which is a division of the University of Southern California, is situated about four miles south of Riverside. It has some 350 acres of all known varieties of citrus under its control, and experiments of every description are conducted, including rootstocks, bud selection, cultivation, pruning, irrigation, fertilizers, soil analyses, insect and fungus control, &c.

Dr. L. D. Batchelor is the Director, and has associated with him gentlemen of world renown in citrus investigation.

I commenced my inquiries at this station, and met Dr. Batchelor, to whom I presented my Commission. He was very kind to me, gave me his undivided attention, and facilitated my every movement. In turn I was introduced to the several Professors and other members of the large staff, who all treated me most courteously, and freely made all information available. In all, I spent over a week at the station, and the knowledge gained is embodied in this report.

It must, of course, be realized that in that short period it was impossible for me to acquire more than a superficial idea of their experiments and activities. One would need many months to study closely their results.

Students from every part of the citrus world, excepting Australia, are studying at this station, spending from two to three years there. It is most regrettable that Australia is not represented, as we undoubtedly have much to learn on citrus culture, and should make every effort to keep ourselves abreast of modern thought and methods.

The buildings are extensive and modern, and contain efficient laboratories, libraries, and equipment.

Experiments were originally commenced at the Rubidoux Experiment Station in 1907, a few miles south of Riverside. This station, however, was abandoned a few years ago, and activities transferred to the present station. The new station was planted in 1917, but no experimental work was conducted, or manures applied until the trees were ten years old, the trees being simply maintained during that period.

The experiments are closely watched by the industry, and the recommendations emanating from the station have been put into universal use by the nurserymen, growers, packers, &c., and have proved of untold value to all concerned.

ORGANIZATION

Marketing and many other sections of the industry are carried out by co-operative bodies capitalized and controlled by growers. The largest concern is the Californian Fruit Growers Exchange, having a membership of over 13,000 growers. Its head office is at Los Angeles, where it occupies a large building recently erected out of its funds. Originally this organization was established for marketing purposes only, but in the course of time it has materially extended its activities, which now embrace field and cultural problems, supplies, by-products, packing house supervision, fertilizers, fumigation and general pest control, also having its own legal department. In fact every phase of the industry is dealt with. The exchange is really a wonderful business organization, highly efficient, and of immense benefit to members. There are over 20 district Exchanges connected with and controlled by the head office and these are in close and constant touch with growers, packing houses, railway companies, &c. These sub-exchanges are equipped with a multi-telegraph system, and the machines are continually giving out reports regarding markets, condition of fruit on arrival at markets, and other essential details.

The exchange controls 75 per cent. of the production of citrus in California, embracing most of the smaller growers, some of whom would be considered large in Australia. The balance is handled by another co-operative body, the Mutal Orange Distributors (10 per cent.), and individual large growers and dealers.

Bulletins and wireless broadcasts are frequently supplied to growers, giving all the latest information and advice.

The Exchange controls all its members' export and advertising. Advertising is conducted on an enormous scale, and cost the Exchange £400,000 in 1935.

The words "Sunkist" and "Red Ball" are registered by the Exchange for use in connection with its first and second grade brands respectively, and

all fruits packed by houses operating under these brands are so branded on the rind. Close supervision is maintained by the Exchange to keep the quality of the fruit up to Exchange standards, which are strictly enforced.

It was my good fortune to attend the 1935 annual conference of the exchange, at which 250 to 300 delegates were present, including District, Exchange and Packing House managers. It was rather interesting to learn that their problems have much in common with ours.

STATISTICS

During my inquiries I was able to gather the following statistical information relative to citrus acreages and production, which will serve to indicate to what tremendous proportions the industry has reached in America. The figures are abstracts from official returns issued by the Federal and State Departments of Agriculture, and the Fruit Growers Exchange.

United States acreage and packed box Production

	Acreages, 1935.	Production. 4-year Average, 1921-1924. Boxes.	Production. 1934-1935. Season. Boxes.
Oranges	498,000	30,988,000	64,241,000
Grapefruit	192,000	8,554,000	21,357,000
Lemons	52,000	—	10,400,000
Total	742,000	39,542,000	95,998,000

California and Arizona acreage and Production

	Acreages, 1935.	Production, 1934-1935 Season. Boxes.
Oranges	239,835	45,900,000
Grapefruit	20,600	3,407,000
Lemons	52,000	10,400,000
Total	312,435	59,707,000

Of the 237,000 acres of oranges in California, Washington Navel oranges comprise 100,000 acres, the balance being Valencias.

Thousands of carloads of citrus are converted into drinks each year. In fact I have heard it stated that this State (California) consumes as many oranges in the form of drinks as in fresh fruit.

Recently a formula has been discovered for canning orange juice, and last year 1,386,000 boxes, representing 50,000 tons of citrus, were absorbed in this manner.

The following were the average gross f.o.r. prices obtained per packed box at despatching stations in California :—

	Values *s. d.*	Marketing Periods.
Winter Oranges	8 0	November-April.
Summer Oranges	8 9	May-October.
Grapefruit	6 2	November-April.
Lemons	11 4	November-July.

In the 1934–1935 season, 2,500,000 boxes of citrus were exported (other than to Canada) from the United States of America.

CITRUS PRODUCTION, RETURNS AND COSTS

The following tables were compiled by the Agricultural Extension Service, University of California, United States Department of Agriculture, and cover the period February 1, 1934, to January 31, 1935. Accurate figures were kept by the growers concerned, and submitted monthly. The prices are for fruit delivered to the Packing House door in field boxes. Labour costs included cultural, picking and haulage, and the value of the operator's own labour, but not as salary for management. Cash overheads include general expenses, county taxes, machinery repairs and insurance. Material costs include water, fertilizers, sprays and frost protection. Depreciation is on plant and improvements.

Navel Oranges (Riverside County)

Number of Records.	More Profitable Orchards.	Less Profitable Orchards.	Average All Orchards.
Total acres covered	6	6	12
Average acres	81	72	153
Average age trees	37	38	38
Average No. trees per acre	89	91	90
Average yield packed boxes per acre	261·6	163·5	215·5
	£. s. d.	£. s. d.	£. s. d.
Average price per packed box	0 5 2	0 4 2	0 4 8
Income per acre	67 8 6	34 10 0	50 19 3
Cultural labour cost per acre	6 5 6	8 11 5	7 8 6
Harvesting cost per acre	6 8 5	3 13 0	5 0 9
Total labour cost per acre	12 13 11	12 4 5	12 9 3
Material cost per acre	12 12 2	12 3 0	12 7 7
Cash overhead cost per acre	6 17 10	6 11 8	6 14 9
Total cash cost per acre	32 3 11	30 19 1	31 11 6
Depreciation per acre	2 12 4	1 14 5	2 3 5
Total cost per acre	34 16 3	32 13 6	33 14 11
Net income per acre	32 12 3	1 16 6	17 4 4
Grade percentages of fruit	Per Cent.	Per Cent.	Per Cent.
Fancy	72·2	53·0	62·6
Choice	12·1	7·3	9·7
Standard	10·4	5·9	8·2
Unclassified	·2	32·6	16·4
Culls	5·1	1·2	3·1
	100·0	100·0	100·0

CONCLUSION

In concluding this report I think it only fitting to emphasize that the success attending citrus production and marketing in the United States has been attained after much endeavour by the following factors :—The concentration of citrus in districts entirely suited to its successful culture. The suitability of rootstocks and selection of buds from proved trees as regards quality, quantity and continuity of production. The elimination of uneconomic and off-type fruits. The scientific study and application of the requirements of

the soil and tree, particularly in respect to fertilizers and irrigation. The control of pests and diseases. Efficiency of organization, packing houses, transport and marketing. Advertising and creating public demand.

We, in Australia, are facing similar problems that America had to contend with 30 years or more ago, and it is only by commencing at the source of production that can ever hope to make the industry efficient.

In order to place the citrus industry in Australia on a sound and economic basis, I consider it desirable that the Federal Government, the State Government and/or the Industry should station a competent man in California for a period of not less than two years, in order that he could keep the industry in this country thoroughly conversant with every development taking place within the industry in the United States of America ; that no further plantings of citrus be made except in proved localities ; that growers and others associated with the industry take early steps to adopt the following practices :—

(*a*) In the selection of nursery trees to purchase only those which have been budded from selected trees on to sweet or sour orange stocks.

(*b*) To eliminate all off-type and non-profitable varieties.

(*c*) To plant efficient breakwinds.

(*d*) To apply heavy annual dressings of animal manures and nitrogen, and to grow cover crops.

(*e*) To apply lighter and more frequent irrigations, even if the additional cost has to be met by reduced cultivation or other means.

(*f*) To take drastic steps to eradicate all pests, particularly red scale.

(*g*) To prune the trees only lightly, but trimming out dead wood and all growth near the ground.

(*h*) That clippers, picking bags, and gloves be used in harvesting.

(*i*) That, where practicable, harvesting should be done by selected men under expert supervision.

(*j*) That gloves be used in the packing houses in all hand operations.

(*k*) That every effort be made to have interstate and export fruit transported in refrigerated rail vans under a speedy service, particularly during the spring and summer months.

SOME ASPECTS OF SOIL CONSERVATION

BASED ON OBSERVATIONS IN THE CENTRAL AND NORTH KAVIRONDO NATIVE RESERVES

THE main factors affecting the extent of water erosion on unoccupied land may be classified as follows :—

(a) Rainfall, particularly maximum precipitation during storms.
(b) Degree of slope.
(c) Amount and type of soil cover.
(d) Nature of the soil.

Of these, the first two may be said to be for all practical purposes beyond human control ; both (c) and (d), however, are susceptible of variation, and in fact as soon as land comes under what is usually known as " beneficial occupation " are immediately subject to deterioration. With the advent of human occupation and its concomitants, agriculture and the keeping of stock, there enters a fifth factor, which by virtue of its effect on the pre-existing conditions is of major importance. This factor—

(e) Density of population,

is closely related to the system of land tenure and of agricultural practice of the natives of any district, and there are indications that it controls them to a large extent. With the more obvious benefits of civilization, freedom from intertribal raids, better nutrition and living conditions due to more varied food and cash crops, decreased mortality among human beings and stock as the result of the medical and veterinary services, all helping towards a rapid increase of the population, there exists necessarily a state of flux, but in general it appears that the greater the density of the population the more highly developed is the system of land tenure. That is, the more widely the idea of the private ownership of land is accepted.

It is the purpose of these notes to discuss some of the problems of soil conservation in native reserves, mainly in relation to this factor. Naturally there can be no hard and fast classification of population density, and there must be important differences due to climate, soil and topography between districts of the same density of population, but it may be sufficient if the following three arbitrary divisions are made :—

(1) Sparse population, up to 150 per square mile.
(2) Moderate population, 150 to 300 per square mile.
(3) Dense population, over 300 per square mile.

* By A. W. Thompson, Assistant Agricultural Officer, Kenya, in *The East African Agricultural Journal*, Volume IV., No. 4., January, 1939.

(1) *Sparsely Populated Districts.*—The inhabitants are usually pastoral rather than agricultural. The percentage of land under cultivation being small, each family uses only enough to provide itself with food, except in districts where there is an established cash crop such as cotton or sesame, and a small additional acreage is cultivated. *Shambas* are normally used for only two or three years and then allowed to revert to grass or bush. A typical cropping system is :—

1st year : Short rains : Sesame or legumes.
2nd year : Long rains : Maize, sorghum, and finger millet.
2nd year : Short rains : Sweet potatoes.
3rd year : Long rains : Maize and sorghum.
3rd year : Short rains : Sweet potatoes.

The system starts with the short rains, as new land is usually broken up after the main long rains crops have been planted. It naturally varies considerably according to the climate and soil, an extreme case being at Kadimu in Central Kavirondo where much of the soil is so poor that it can only be cropped for one year. The type of plant growth which appears in abandoned *shambas* also varies, but over that very large area where *Cymbopogon* sp. is naturally the dominant grass, for example between Kakamega, Mumias and Malakisi, reversion follows the lines of—

1st year : Weeds and *Digitaria* sp.,
2nd year : *Imperata cylindrica*,
3rd year : *Cymbopogon* sp.,

and it is remarkable that not only are *Imperata cylindrica* and *Cymbopogon* sp. dominant during the periods in which they occur, but they often exist as almost pure stands. Eventually the hardier bushes and small trees of the Combretum savanna type reappear.

It is difficult to give any figure for the resting period of the land after its reversion, but it seems probable that it is at least sufficient to permit of the recovery of the soil from the moderate demands made on it by the crops taken off. In such circumstances the danger of rapid deterioration of the soil is not formidable, especially as the wide choice of land for cultivation results in most *shambas* being situated on gently sloping land. This minimizes the tendency to erode, and makes erosion controllable by simple methods and a small expenditure of energy on the part of the cultivator. With an increasing acceptance by the native of the necessity for such soil control measures, the prohibition of indiscriminate tree felling and grass burning, and the encouragement of the use of manure and compost, there is little danger of soil conservation becoming a major problem in the more sparsely populated districts. There are of course occasional patches of soil which from treading by cattle, overgrazing or other causes have been damaged in the past, but these are gradually being reconditioned either by the communal efforts of the natives themselves or by the labour paid from Local Native Council funds. This is attended by no difficulties arising from the system of land tenure,

since such a thing can scarcely be said to exist, all grazing being communal and individual rights to land being recognized only so long as any particular piece is under cultivation.

(2) *Moderately Populated Districts.*—In these the cropping system and the virtual lack of system of land tenure differ little from those in the more sparsely populated districts, except that the clan elders have considerable control over the allocation of land to individuals. There is naturally, however, a greater potential danger of over-grazing and of treading erosion, of the depletion of the plant food reseves in the soil by prolonged cultivation and of the use of steeply sloping land for *shambas*; and consequently an increasingly urgent necessity for the application of mixed farming principles by the natives, in order that grazing may be conserved, the soil used to the best advantage and its productivity maintained by manuring and the use of compost. At the same time these principles are not easy to inculcate in a native mentality slow to appreciate the impending danger, distrustful of new ideas, and averse from them when they entail additional labour.

(3) *Densely Populated Districts.*—In these all the land is individually owned; in some locations sales of land for cash take place between natives and are recognized as permanent. Not even such grazing as results from the temporary abandonment of cultivation is communal, although provided it is not fenced in or the owner's cattle are not tethered on it, it is customary for the cattle of other natives to graze it. Only a small percentage of the land can be termed grazing, and this consists in the main of steep and rocky hillsides, swampy river beds, surrounds of schools and churches, and occasional football fields; with the exception of the hillsides, which are usually covered with *Cymbopogon* sp., it consists of lawn-like sward kept permanently in this state by intensive grazing. The proportion of cultivated land which is allowed to rest is but a small percentage of the total and rarely reverts to grass. At the most it has a weed fallow of a year or less, or in a few cases it is allowed to become covered with the succeeding growth of *Imperata cylindrica*, which is cut for thatching. So great is the extent of cultivation that very steep slopes, very rocky land, and even odd patches of soil on the sides and tops of hills are under almost continuous cultivation, with a consequent rapid exhaustion of the soil and increase of erodibility. The exhaustion of the soil is visible in the very sparse weed growth which occurs on the infrequent patches of fallow land, and the natives themselves comment on the decreasing yields of their crops.

In view of the large amount of unsuitable land under cultivation, soil conservation presents difficulties which do not occur in the more sparsely populated districts, and it is improbable that cultivation of this unsuitable land could be prohibited without hardship to the natives concerned, or that measures which did not include a considerable reduction of the population could be really effective. There is already some tendency to emigrate, but it is insufficient to relieve the situation. The real necessity is for larger average holdings, which would enable the natives to confine their cultivation to suitable land, would allow of a proper rotation of crops and resting period, and would provide grazing for a small herd of cattle. Even as things are now, some improvement would be effected were it possible to confine cultivation to the tops and higher

slopes of the ridges, using the bottoms and steeper lower slopes for pasturing with paddocks, and taking advantage of the reeds, of which there are usually plenty in the streams, for litter for compost-making. An analysis of human and stock population of North Kavirondo is given in the annexed table in terms of three arbitrary degrees of density :—

Density.	Average Population	Cattle per Sq. Mile.	Cattle per Person.	Acres per Unit.
Sparse—				
Pastoral	80	346	4·4	1·5
Agricultural	120	190	1·6	2·1
Total	90	292	3·1	1·7
Moderate	210	150	0·7	1·8
Dense	650	196	0·3	0·7

The figures in the last column are obtained by dividing the total area under consideration by the total of the human and stock populations. If it be assumed that the amount of land required by each native for cultivation is one acre, then the available area for each head of stock is :—

	Acres.
Sparse, pastrol	1·6
Sparse, agricultural	2·7
Sparse, total	1·9
Moderate	2·9
Dense	—
Average for district	1·9

In other words, if the human and stock population of North Kavirondo was uniformly distributed throughout the district, a family of three owning 5 head of cattle would have at its disposal approximately 13 acres of land, of which three acres would be under cultivation and ten acres grazing.

In contrast with this there are the very densely populated parts, with over one thousand people to the square mile, equivalent to about half an acre of land per person exclusive of cattle.

SOIL CONSERVATION METHODS

The one most generally in use is the digging of contour trenches, stopped at intervals of not more than 20 feet, the earth removed being used to form a bank on the lower side which is planted with Napier grass, *Cymbopogon* sp., *Paspalum* sp., or some other easily available plant the roots of which will bind the soil. Of these, Napier grass has the advantage that once established it can be cut back from time to time and used for cattle fodder, a considerable benefit where grazing is scarce. The earth bank is gradually built up with silt from the trench until it reaches the requisite size, when the trench is allowed to silt up, the task of preventing erosion devolving on the bank. In time more soil will be retained on the top side of the bank until there is a considerable space which is level and on this silt will continue to be deposited whenever there is heavy rain, owing to the decrease in the run-off velocity of the surplus water due to its encountering the line of grass.

Where available, trash from the previous crop is used to make temporary contour lines ; this, however, has its limitation in that in the drier districts, where supplies of firewood are small, almost all dry maize and sorghum stalks are used for fuel.

On stony ground rock walls are built along the contour, and in the more sparsely populated districts where there is no shortage of land for cultivation strips of grass or bush are left at intervals down the slope to restrain any movement of soil.

In addition to these methods for assisting the absorption of the excess rain which actually falls on cultivated soil, it is necessary to deal with what may be termed—

NUCLEI OF EROSION

Among these are :—

(*a*) Stony hillsides.
(*b*) Rock or murram outcrops.
(*c*) Buildings, especially if they have hard bare surrounds.
(*d*) Paths.
(*e*) Boundary furrows between *shambas*.
(*f*) Take-off drains from roads.
(*g*) Over-grazed areas.
(*h*) Ant-hills.
(*i*) Inefficient soil control measures on cultivated land.

With these the following measures are employed to minimize erosion :—

(*a*) *Stony hillsides.*—Tree planting on the tops of the hills and in strips along the sides. Rock walls wherever there is cultivation, and the improvement of ground cover where the land is under bush or grass. In many cases, however, slopes are so steep and the amount of rock so large that some run-off is inevitable, and storm drains at the base of the hill are essential in order to protect arable land below.

(*b*) *Rock or murram outcrops.*—Tree planting as near as possible to the outcrops and among the rocks if, as is usual, they are interspersed with patches of soil, so that the leaf canopy may break the fall of heavy rain. The diversion of surplus water by means of storm drains.

(*c*) *Buildings.*—Storm drains where possible, and in districts where bananas are planted on the lower sides of villages, the use of banana trash in contour lines to check run-off and increase absorption.

(*d*) *Paths.*—Natives are encouraged to fence along both sides of the main paths with quick-and close-growing material such as *Euphorbia* sp., *Dracaena* sp., and *Coleus* sp., to prevent erosion from the adjoining *shambas* which are considerably higher than the paths, to build turf banks to reduce the speed of run-off and to allow grass to grow between.

(*e*) *Boundary furrows between shambas.*—These are of almost universal occurrence throughout the Kavirondo country, and generally run down hill, frequently from the top of a ridge to the bottom. They are caused in the first instance by adjoining land-holders scraping the earth at their joint boundary towards their respective *shambas* in order to demarcate the boundary. This results in a shallow trench which increases with each year's cultivation and erosion until it may

eventually become three or four feet deep. As the furroew deepens, the soil on both sides is washed down, and often there is a strip of two or three yards wide on either side which is down to subsoil and will produce nothing. Nevertheless, these slopes are cultivated by the owners, partly to prevent couch spreading from them to the *shamba* proper, and partly owing to the fear that otherwise the adjoining land-holder would encroach. Natives are encouraged to refrain from cultivating the slopes, to build earth or turf banks across the furrows, and to plant them with hedges of quick-growing indigenous plants.

(*f*) *Take off drains from roads* are stopped at close intervals with low turf banks to reduce the velocity of the run-off, and grass is allowed to grow between. Precautions are taken to see that the top of the first bank is far enough below the surface of the road to obviate flooding. Cultivation of the land within a few feet of either side of the drain and for some distance below the spillway is discouraged.

(*g*) *Over-grazed areas* are improved where possible by destocking, by digging short trenches at intervals to retain surplus water and so increase the soil moisture, and where necessary by the planting of suitable grasses, *Cynodon*, *Paspalum*, *Pennisetum*, &c.

(*h*) *Ant-hills* are dangerous in that their steep slopes prevent absorption of rain during storms and increase the amount of water round the bases. Natives are encouraged to refrain from cultivating them.

(*i*) *Inefficient soil control measures.*—These sometimes occur where the willingness of the individual native to undertake the work is greater than his capacity to carry it out effectively, and will disappear in the course of time as his standard of education in agricultural practice is improved.

It will be realized that the efforts of the individual cultivator are in the circumstances not enough in themselves, and that not only is a certain amount of communal effort necessary but also a good deal of co-operation between owners of adjoining holdings. As to the former, it is obviously useless for the owners of land at the bottom of a steep rocky hill from which the run-off is considerable to carry out soil control measures on their cultivated land, however satisfactory these measures may be in themselves, unless the land is first protected from storm water from the hill. The work involved in such protective measures should devolve equally on all holders of the land affected by them. Similarly as regards co-operation, it is a waste of energy on the part of A at the bottom of a slope to put in control measures which would be effective in respect of his own land, if B higher up does nothing to prevent the storm water from his land pouring down and destroying A's work. While there is no doubt that in general the necessity for soil control is accepted by the natives, it is not always easy to obtain that concerted effort which produces the best results with the least expenditure of energy. A minor obstacle is that the wealthier natives, such as traders, teachers and artisans, who are frequently large land-holders, are often unwilling to undertake the manual work entailed by soil

control measures themselves and are loath to utilize their paid labour for such work. It can, however, be said with confidence that the propaganda and demonstrational work of the last few years has produced such an effect on the native mind that the practical application of soil control measures in the reserves is increasing with gratifying rapidity.

I am greatly indebted to Mr. W. Lyne Watt, Senior Agricultural Officer, Nyanza Province, and to Mr. T. Y. Watson, Agricultural Officer, Kakamega, for suggestions and helpful criticism in connexion with these notes.

COVER CROPS*

THERE are a number of cover plants employed to protect the soil and reduce weeding costs on land planted with permanent crops. The list of species cultivated is a large one, but the following selection has so far proved the most useful for general purposes. With the exception of *Mikania scandens*, which belongs to the Natural Order Compositae, all plants described are leguminous.

CALOPOGONIUM MUCUNOIDES

A vigorous climbing or creeping herb with trifoliate leaves forming a dense mat of foliage, 1 to 2 feet high. The flowers are produced in short racemes, small, pale blue in colour. The flattened seeds are brown, and number about 34,000 per lb.

This cover will thrive on a wide range of soils, but is of the greatest value on new clearings, where it will cover the land in four months from sowing. When the shade of the permanent crop becomes dense, the growth of the cover weakens and in time dies down. Calopogonium has proved a valuable cover plant in young rubber and oil palm clearings, either sown as a sole cover crop or as a mixture with Centrosema or Pueraria. The advantages of sowing a mixture are seen when the permanent crop matures, as Centrosema is more hardy than Calopogonium, and gradually replaces the latter, while Pueraria will continue to thrive under shade. Although Calopogonium is liable to die down early, natural regeneration occurs under suitable conditions.

CENTROSEMA PUBESCENS

A twining herb with trifoliate leaves, forming a loose mat of foliage about 18 inches deep on open land. It climbs any support with which it comes in contact. Flowers pale mauve with purple lines in the centre; three to five produced on a raceme. The seeds are flattened, brownish-green with dark green markings. The number of seeds per lb. is about 16,000.

Centrosema makes rather slow growth in the early stages, but when properly established forms an excellent cover. If the soil is sufficiently fertile, or where the permanent crop is manured, this cover plant will remain effective for many years and continue to thrive under shade. Care is necessary to prevent it from climbing young trees or retarding the growth of the permanent crop by excessive vegetation immediately below the trees or palms. For new clearings or replanting of rubber and oil palm areas it may be grown in combination with Pueraria, and a seed mixture consisting of 5 lb. Centrosema and 2 lb. Pueraria per acre has been found most suitable for this purpose.

* *Department of Agriculture, S. S. & F. M. S., Leaflet* No. 6.

DOLICHOS HOSEI SARAWAK BEAN

A low, creeping, perennial herb of rather weak growth. Leaves trifoliate and slightly hairy. Several small yellow flowers are produced on a short raceme. The seed is brown in colour, blotched with chocolate markings. About 18,000 seeds weigh 1 lb.

The Sarawak bean thrives on a loose porous soil and is of particular value on the lighter types of alluvial coastal clay. It is most difficult to establish on undulating land that has suffered from soil erosion. Further, it is a shallow-rooting, moisture-loving plant, and will thrive under dense shade. It has a particular liking for wood-ashes, and on new clearings with abundant residues from burnt-off jungle, or where wood-ashes are applied to the land, vigorous growth is made. Owing to its prostrate habit, little or no trouble is experienced in preventing it from encroaching upon any permanent form of cultivation. It is an excellent cover crop in the fruit orchard or on flat nursery land.

INDIGOFERA ENDECAPHYLLA

A low, creeping herb with dark green pinnate leaves and small purplish-pink flowers. The seeds are minute, light brown in colour and number about 220,000 per lb.

This cover plant thrives on land which has not suffered from erosion and it requires a moist rooting surface. It thrives from sea-level up to considerable elevations and is a suitable cover crop under tea. The plants send out trailers, which produce numerous adventitious roots, thus forming a dense low mat over the land. Indigofera is stated to develop a strong tap-root which assists materially in opening up the soil.

MIKANIA SCANDENS

A twining indigenous herb belonging to the Natural Order Compositae. Leaves opposite, 2 inches long. Flowers whitish, small and inconspicuous; produced in heads 2 inches wide. The seeds are so small and light that it is impracticable to collect them. The plant when once established spreads with extraordinary rapidity and owing to its twining habit all weed growth is completely checked.

Mikania will grow successfully on almost all types of soil but has been observed to make the most luxuriant growth on heavy alluvial coastal clays. Under such conditions it will cover open land with a dense mat within one month of planting the cuttings, hence it is called the "mile a minute" plant. Although non-leguminous, a dense mat of decaying organic matter is formed on the land. With present knowledge it is not possible to compare its value with the better known leguminous plants, but owing to its rank vigorous growth it appears to have a depressing effect on the development of young rubber and coconuts, particularly if the cover is not kept well away from the base of the trees.

PUERARIA PHASEOLOIDES

A strong twining herb, often attaining a considerable size in the wild state in Malaya. Leaves large, trifoliate, hairy. Flowers in racemes in scattered pairs, mauve in colour. Seeds small, dark brown. The number of seeds per lb. is about 37,000.

This cover plant thrives on the heavier types of soils and has proved successful on the alluvial clays of the coast. When once established, a dense thick cover, several feet high, is formed. The plant will continue to thrive under shade, but growth is less robust. It is a rather shy flower, consequently seeds are difficult to collect in quantity. Fortunately, Pueraria may be readily propagated from cuttings, which are lifted with numerous adventitious roots.

Owing to its hard coat Pueraria seed absorbs water irregularly and in consequence germination is spread over a long period. In order to obtain more rapid germination the seed may be soaked in water for three days and at intervals of 24 hours all swollen seed should be removed and sown immediately. A 1/9th inch mesh sieve is suitable for separating the swollen seeds. Alternatively, the difficulty may be overcome by rubbing the dry seed between two sheets of wire mosquito netting or abrading the seed coats in a mortar by mixing it with sand and stirring vigorously. As stated previously, this cover crop is often grown as a mixture with Centrosema on both new clearings and replantings.

PROPAGATION

The several methods of propagating the cover crops described are detailed below in tabular form. Cuttings may be used when seed is expensive or difficult to obtain.

In planting cover crops, whether from seed or cuttings, advantage should be taken of rainy weather and the land be as clean of weeds as possible. Before planting, the rows are lightly forked or cultivated. In the case of small seeds, an admixture of sand facilitates distribution. Seeds that have a hard seed coat or have been stored for some time will germinate more readily if soaked for a period of 24 hours in water raised to a temperature of 110°F. Seeds so treated should not be allowed to dry before sowing. On soils where erosion has already taken place, the addition of either basic slag or rock phosphate mixed with the seed in the proportion of about 10 lb. of fertilizer to 1 lb. of seed and the mixture sown forthwith assists in establishing the cover plants.

UPKEEP

The main operations in establishing cover crops are systematic weeding between planting and maturity, and removal by hand of all noxious grasses and other growths that may appear through the cover crops. Further, in order to prevent competition for plant nutrients, it is important that a fair-sized circle round the main crop should be kept free from the cover plant.

Digging in the cover plant at intervals of one or two years may be adopted with beneficial results, but when funds are not available for this operation, slashing down the surface growth is recommended to allow of better aeration of the soil.

COVERS UNDER SHADE

According to the Rubber Research Institute it cannot yet be claimed that a satisfactory technique for the establishment and maintenance of a good leguminous cover on mature rubber areas has yet been obtained. There are a few outstanding successes, but these have been generally accounted for by especially favourable conditions. Experience so far has shown that the

important conditions for success appear to be the elimination of root competition, at least in the early stages of establishment, and the use of phosphatic fertilizers ; on sandy soils in particular, extra potash may also be required.

Cover crop.	Method of Propagation.	Rate per acre.	Remarks.
Calopogonium mucunoides ..	Seed	3-4 lb. ..	Rows 3–5 feet apart.
Centrosema pubescens ..	Seed ..	5 lb. ..	Rows 3 feet apart.
Dolichos Hosei ..	Seed ..	5 lb. ..	Rows 3 feet apart.
	Cuttings	8 sacks ..	Rows 3 feet apart.
Indigofera endecaphylla ..	Cuttings (9 ins. long)	4 sacks ..	2ft. × 2 ft. Seed may be used to provide nurseries for cuttings.
Mikania scandens ..	Cuttings (12 in. long)	2 sacks ..	5 feet part.
	Seed ..	3–4 lb. ..	Rows 3 5 feet apart.
Pueraria phaseoloides ..	Cuttings (2 ft. long)	10 sacks ..	3 ft. × 3 ft. Seed may be used to provide nurseries for cuttings.

Investigations have been carried out by the Institute in the inoculation of seed with the appropriate symbiotic organism ; in nearly all cases inoculation has been found to stimulate the rate of establishment of leguminous covers.

REFERENCES

Articles on cover crops are obtainable from the Agricultural Economist, Department of Agriculture, S.S. and F.M.S., Kuala Lumpur.

Cover Crops and Green Manures, *Malayan Agricultural Journal*, Vol. XVI., No. 7, price 50 cents.

The Effect of Cover Crops on Soil Moisture, *Malayan Agricultural Journal*, Vol. XVIII., No. 10, price 50 cents.

The Editor,
The Tropical Agriculturist,
Peradeniya.

Jaffna,
May 22, 1939.

INTRODUCTION OF A NEW GRASS FOR CEYLON PASTURES

SIR,

IT is well known that large extents of grain-growing areas in the United States of America had been denuded of their top soil through the mechanical operations of cultivation which made the surface soil to be in a fine state of tilth, helping the blowing-away of the soil by strong winds prevalent in the area.

With a view to remedy matters it is proposed to have 20,000 acres (31,250 square miles) in the north-western part of the United States sown with grass brought from the steppes of Russia to prevent valuable farm land from becoming a desert.

It is said that the grass in question is eminently suited to fix the soil left denuded by the cutting down of trees and the breaking up of the soil through intense mechanical cultivation. It is said to stand both extreme cold and drought.

So far, about 5 million acres have been planted with the grass with the result that the land which was turning desert has now been transformed into valuable grazing land.

I would suggest that the Agricultural Department do get samples of this grass for experimental cultivation here. If successfully planted here it will help to prevent soil erosion besides solving the pasture problem specially in the Dry Zone of the Island where the grass may be found to be a useful introduction, particularly as it is drought-resistant.

I am, Sir,
Yours in service,
(Sgd.) C. ARULAMBALAM.

"MEETINGS, CONFERENCES, &c."

REPORT OF THE PROCEEDINGS OF THE FIFTH MEETING OF THE CENTRAL BOARD OF AGRICULTURE

THE fifth meeting of the Central Board of Agriculture was held in the Board Room of the Department of Agriculture at 2.30 P.M. on Friday, March 17, 1939.

Mr. E. Rodrigo, C.C.S., (Acting Director of Agriculture and Chairman of the Board) presided and the following members were present :—Sir Wilfred de Soysa, Messrs. S. F. Amerasinghe (Sr.), S. Armstrong, C. Arulambalam, A. C. Attygalle, P. B. Bulankulame, Dissawe, Dr. Reginald Child (Director, Coconut Research Scheme of Ceylon), Messrs. V. Coomaraswamy (Acting Conservator of Forests), M. Crawford (Deputy Director, Animal Husbandry and Government Veterinary Surgeon), C. M. W. Davies (*vice* the Chairman, Planters' Association of Ceylon), E. C. de Fonseka (Jr.), C. N. E. J. de Mel (Principal, Farm School), Messrs. G. de Soyza (Acting Registrar of Co-operative Societies), Bertram de Zylva, M. M. Ebrahim, James P. Fernando (Chairman, Low-Country Products Association), James Forbes (Jr.), Bruce S. Gibbon, Dr. J. C. Haigh (Botanist), Mr. A. K. J. Henderson (Acting Commissioner for the Development of Agricultural Marketing), Dr. J. C. Hutson (Entomologist), Mr. Montague Jayawickreme, Dr. A. W. R. Joachim (Chemist), Messrs. A. L. Johnpulle (Acting Agricultural Officer, Plant Pests), S. M. K. B. Madukande, Dissawe, T. H. E. Moonemalle, Mudaliyar S. Muttutamby, Dr. R. V. Norris (Director, Tea Research Institute of Ceylon), Mr. T. E. H. O'Brien (Director, Rubber Research Scheme of Ceylon), Dr. S. C. Paul, Messrs. Wilmot A. Perera, B. M. Selwyn, Rolf Smerdon, R. H. Spencer-Schrader, S. G. Taylor (*vice* the Director of Irrigation), Mudaliyar N. Wickremaratne, Mr. A. A. Wickremasinghe, Rev. Father L. W. Wickramasinghe, Col. T. Y. Wright and Mr. M. Park, Secretary.

The following visitors were also present :—Messrs. B. W. Bawa, C. B. Redman King, W. C. Lester-Smith (Chief Advisory Officer, New Rubber Planting Scheme), T. M. Z. Mahamooth, W. Molegode, Kenneth Morford, G. K. Newton and J. Vinson.

The following members intimated their inability to attend the meeting :—Messrs. H. W. Amarasuriya, N. J. Bannerman, Marcus S. Rockwood, W. A. Muttucumaru, C. L. Wickremesinghe (Commissioner of Lands), and C. Huntley Wilkinson.

The Chairman read a letter from Mr. R. C. Scott, Chairman, Planters' Association of Ceylon, regretting his inability to attend and asking that Mr. C. M. W. Davies, vice-chairman, might deputize for him. The Chairman welcomed Mr. Davies.

CONFIRMATION OF MINUTES

The draft minutes of the fourth meeting of the Board, held on November 17, 1938, copies of which had been sent to all members, were confirmed with a minor amendment.

PERSONNEL OF THE BOARD

The Chairman reported that the following members who were out of the Island had been granted leave of absence :—Messrs. R. P. Gaddum, R. G. Coombe, A. T. Sydney Smith, F. A. E. Price and J. P. Blackmore.

The Chairman welcomed Mr. James P. Fernando, Chairman, Low-Country Products Association, who had become a member *ex officio* in place of Mr. J. Tyagaraja.

Mr. R. C. Scott was elected a member of the Executive Committee of the Board in place of Mr. R. P. Gaddum, resigned.

ACTION TAKEN ON THE DECISIONS OF PREVIOUS MEETINGS OF THE CENTRAL BOARD OF AGRICULTURE

The Chairman made a statement of the action that had been taken on motions passed at the fourth meeting of the Board and on subjects raised at earlier meetings on which action had reached a stage of finality.

The following is a summary of the statement :—

(1) *Census of plough cattle.*—The Director of Statistics has undertaken to collect the required data.

(2) *All-Island Agricultural Shows.*—The sub-committee appointed met and prepared a report which had been circulated and which would be presented later.

(3) *Composting.*—A leaflet giving fuller information was being prepared by the Chemist, Department of Agriculture.

(4) *Conversion of Vadamarachchy Lagoon.*—This subject would be considered at the Survey and Settlement Conference in 1939.

(5) *The control of village fairs.*—The Hon. the Minister for Local Administration had reported that the Village Committees have wide powers to control village fairs under the new Village Communities Ordinance and had suggested that, should the Central Board of Agriculture wish to draw up a memorandum for the guidance of Village Committees, he would be pleased to circulate it to the Village Committees.

(6) *Bureau of Agricultural Statistics.*—A motion recommending the formation of this Bureau was passed by the Board in 1935. The Statistics Ordinance, No. 44 of 1935, which was passed subsequently, appeared to meet the request and statistics were being collected in respect of the main agricultural products of the Island.

(7) *Cattle shows.*—The first cattle show, held in Colombo in March, 1939, had been very successful.

(8) *A scheme of farming as a career for educated young men,*—and

(9) *The provision of facilities for growing food crops near estates.*—These two resolutions were still under consideration by the Executive Committee of the Central Board of Agriculture.

REPORT OF THE SOIL EROSION COMMITTEE

In the absence of Mr. R. P. Gaddum, Chairman of the Soil Conservation Committee appointed by the Central Board of Agriculture, Mr. W. C. Lester-Smith presented the report with the following remarks :—

" At its meeting, in July last year, a despatch, from the Secretary of State for the Colonies, on the subject of soil erosion was referred to this Board. The Secretary of State pointed out the accepted fact that neglect by any country to ensure the conservation of its soil would lead that country to permanent impoverishment. He considered it necessary, in the interest of future generations, that positive measures to ensure the proper conservation of the land should be initiated by all Governments, who should not regard the problem as a subject of particular concern to only one or two Departments of Government, but as a major question of general policy.

After hearing the tentative suggestions made by the Director of Agriculture, this Board appointed a Committee to consider the suggestions contained in the despatch from the Secretary of State, and to report how effect could best be given to them.

The report of this Soil Conservation Committee of which I was the Secretary, I have the honour of presenting formally to the Board. Copies of this report, I understand, have already been circulated to all members of the Board.

In presenting this report to you may I briefly summarize the views of the Committee. They were that the Ceylon Government should give effect to the suggestions made by the Secretary of State. That for this purpose a separate and independent central co-ordinating body, with a technical character, should be established in Ceylon to deal with all matters concerning soil erosion. That this body, of which the Land Commissioner should be Chairman, should consist of representatives of all those most intimately connected with the use and control of the land.

In these respects the recommendations of the Committee agree with the views expressed by the Director of Agriculture at the last meeting. The Committee, however, although in sympathy with the idea that the suggested Soil Conservation Board should have executive powers, found themselves unable to recommend such a proposal. The Committee considered that a Board of this type with executive powers would be inconsistent with the present constitution of Government, and they therefore recommend that the Board they have envisaged should be advisory to the Executive Committee of Agriculture and Lands on all matters concerning soil erosion in Ceylon.

Annexed to this report is a brief summary of the legislative and other action already taken in various countries for the conservation of their soil : and, while it is in no way suggested that any of these particular examples should be followed in Ceylon, it is felt that they do indicate the beginning of the widespread recognition of that land-grabbing and soil-deteriorating monster from

whose far-reaching and despoiling tentacles no part of the world is safe. Least of all can Ceylon claim immunity, for we have had this octopus in our midst for several centuries. It is true that it has been recognized since 1878; it is also true that various piecemeal and isolated efforts have been made to reduce its ravages and to stimulate a wider interest in this combat, but there has been no effective joining of forces and without concerted action these endeavours are of little avail.

Erosion is of two types: normal or geologic erosion and induced erosion. Normal erosion is an intrinsic part of soil formation; it is an extremely slow process which nature when left to herself regulates and retards. Induced erosion, however, is erosion of an accelerated type which is a necessary accompaniment of man's disturbance of the balance of nature.

Ceylon, in company with many other tropical countries regularly experiences intensive rainstorms, when a large proportion of the rain is precipitated during a relatively short space of time. Every area of land on which this rain falls has a limit to the rate at which it can absorb this water, and it is the quantity which falls in excess of this that becomes surface run-off, accumulates and is the main cause of soil erosion. Ceylon is primarily an agricultural country. If its development is to progress and its population is to continue to exist, its soil must be conserved and both the quantity and rate of movement of surface run-off water must be reduced.

Soil erosion upsets the natural balance which exists between land and water; it leads to devegetation and droughts, to floods, silting and extensive damage to communications. These affect each individual adversely and impoverish the community as a whole. A catchment area is the smallest unit on which adequate soil conservation measures can be based. All drainage systems should be adapted to the nature of the catchment area and where the necessary drainage systems do not exist provision must be made for them.

These varied subjects are all vitally interconnected. They must not be left to be the concern of one individual, one group of individuals, or even to one department of Government alone. They concern the whole community and they require careful co-ordination by experts for the benefit of all.

With these comments I commend the Report to the Board and formally move its adoption."

Dr. R. V. Norris in seconding the adoption of the report suggested that the Surveryor-General *ex officio* should be an additional member of the proposed Soil Conservation Board. Mr. Lester-Smith approving of the amendment, the motion as amended was put to the Board and carried.

Mr. Rolf Smerdon suggested that the introductory remarks made by Mr. Lester-Smith should be recorded in the minutes verbatim. The suggestion was approved.

In reply to a question by Mr. Rolf Smerdon, the Chairman stated that he would communicate with the Hon. the Minister for Agriculture and Lands regarding the office of Soil Conservation Officer.

TEA TORTRIX RETURNS

The Board considered the summary of the tea tortrix returns for the period 1928-1937. Dr. Norris stated that the present position in regard to the control of tea tortrix by the parasite introduced from Java was so satisfactory that it was felt that the suspension of the regulations under the Plant Protection Ordinance, No. 10 of 1924, regarding this pest could be safely recommended.

Mr. James Forbes stated that the matter had been considered at a meeting of the General Committee of the Planters' Association of Ceylon and that, as a result, he moved the following :—

" That this Board recommends that the regulations in relation to tea tortrix made under the Plant Protection Ordinance, No. 10 of 1924, and published in the *Government Gazette* No. 7,640 of April 27, 1928, and No. 7,639 of April 20, 1928, be suspended pending further notice."

Mr. Rolf Smerdon seconded the proposal.

In supporting the motion, Mr. Lester-Smith stated that, as far as could be judged from the records, there appeared to be no evidence that collections had done a great deal of good.

The motion was put to the meeting and carried.

PROHIBITION OF THE SLAUGHTER OF BUFFALOES

Mr. Madukande Dissawe spoke to the folowing motion standing in his name :

" In view of the great shortage in this country of buffaloes for agricultural purposes and the large number of buffaloes slaughtered for meat each year, this Board recommends that Government should take early steps to totally prohibit the slaughter of buffaloes for meat."

Mr. Madukande Dissawe stated that there was a great shortage of buffaloes in certain areas and he felt that the sale of buffaloes for meat was largely responsible. He understood that steps were being taken by Government to obtain a census of cattle and to arrange for a better distribution of animals for agricultural purposes. He understood also that the Colombo Municipality had adopted the recommendations of the Central Board of Agriculture regarding the sale of baffalo meat and that, in consequence, the sale had been reduced. He suggested that the Director of Agriculture should ask other municipal bodies to adopt similar measures. In view of these points he asked permission to withdraw the motion, reserving the right to reintroduce it should it become necessary.

The Chairman pointed out that hardly any slaughter of buffaloes for meat existed out of Colombo and that it was therefore not necessary to approach other local bodies.

With the permission of the Board, the motion was withdrawn.

TREE PLANTING IN THE DRY ZONE

Mr. C. Arulambalam moved :

" The Central Board of Agriculture recommends to the Executive Committee of Agriculture and Lands to have a scientific investigation made as

to whether by a planned and systematic planting under State supervision, of high-growing and wide-spreading trees of suitable types throughout the dry zone of the Island, the climatic conditions in that zone could be improved with particular reference to better distribution of rainfall in the zone throughout the year so as to prevent both unseasonable rain and long-continued droughts now characteristic of the dry zone and the cause of serious losses to agriculturists.

This Board further recommends that the proposal embodied in the above resolution be carried out without delay when favourably reported upon by the Scientific advisers of Government."

In introducing his motion, Mr. Arulambalam stated that he felt that the unseasonal weather and persistent droughts experienced in the dry zone during recent years might be due to the destruction of high forests. He quoted from books in which it had been suggested that there is a correlation between the rainfall of a region and the type of vegetation and that the extent of forests affected the rainfall of a country. He felt that if the scientific planting of high-growing trees was undertaken in the dry zone, the rainfall would tend to increase and to be better distributed. He then formally proposed the resolution.

Mr. M. M. Ebrahim seconded the motion.

Mr. V. Coomaraswamy opposed the motion. He doubted the practicability of the undertaking on the grounds of the paucity of suitable trees which could be raised artificially, the uncertain and adverse climatic conditions, the large area (3 to 4 million acres) involved, the protection from the ravages of wild animals necessary, and the scarcity of suitable labour. He stated that the cost of re-afforesting would be high and said that small plantings of Casuarina had cost Rs. 300 to Rs. 400 an acre. Finally, he stated that it had not been proved that forests induced rainfall. He therefore concluded that the motion was incapable of practical adoption.

A general discussion followed, after which the motion was put to the Board and lost.

Mr. S. Armstrong moved and Mr. A. C. Attygalle seconded that the matter be referred to the Executive Committee of the Board for report. The proposal was put to the meeting and lost.

ALL-ISLAND AGRICULTURAL SHOWS

Mr. Wilmot A. Perera presented the report of the sub-committee appointed by the Central Board of Agriculture at the fourth meeting on November 17, 1938, to go into the question of the inauguration of an All-Island Agricultural Show.

The sub-committee recommended that an All-Island Agricultural show should be held annually, suggested certain conditions covering the shows, and recommended that a Standing Committee be appointed by the Board for their control. Mr. Perera moved the adoption of the repoor.

Mr. E. C. de Fonseka seconded.

Mudaliyar N. Wickremaratne opposed the report. He felt that All-Island Agricultural Shows would prove to be a failure financially and that they would not serve any useful purpose. He was of the opinion that, instead, local shows should be fostered.

Mr. S. Armstrong and Mr. C. Arulambalam spoke in support of the adoption of the report.

Mr. M. Crawford suggested, as an amendment, that Colombo be added to the list of places at which shows should be held. Mr. R. H. Spencer-Schrader seconded.

The Chairman pointed out that the contemplated All-Island Shows would implement the work done at local shows and that, far from replacing them, would tend to foster them. The functions of local and central shows were really distinct and there was a definite need in Ceylon for an annual All-Island Agricultural Show.

Mr. Crawford's amendment was accepted and the report, as amended, was adopted by the Board.

The following Standing Committee was appointed by the Board for a period of three years to inaugurate and control the All-Ceylon Agricultural Shows :—

The Registrar of Co-operative Societies ; The Marketing Commissioner ; The Government Veterinary Surgeon ; Sir Wilfred de Soysa ; Mr. Wilmot A Perera ; Mr. U. B. Unamboowe, R. M ; Mr. S. Armstrong ; Mr. Bruce S. Gibbon ; Mr. M. Jayawickreme ; Mr. P. B. Bulankulame, Dissawe ; Mr. C. Arulambalam ; Mr. C. Huntley Wilkinson ; Mr. Marcus S. Rockwood ; Mr. S. M. K. B. Madukande, Dissawe ; Mr. A. Canagasingham ; Mr. F. A. E. Price ; Mr. E. C. de Fonseka (Jr.) ; Mr. L. L. Hunter ; Mr. M. Park.

At the suggestion of the Chairman, the Board approved of the co-option by the Committee of Mr. W. Molegode, Agricultural Officer (Propaganda).

A FIVE-YEAR PROGRAMME OF IRRIGATION POLICY

Mr. S. Armstrong moved—

"That this Board recommends to the Hon. the Minister for Agriculture and Lands that a five-year programme of irrigation policy be adopted to develop the food supply of this Island to a satisfactory condition and that more money be allocated for providing irrigation facilities to the existing schemes mentioned in the 'Reports of the District Sub-Committees appointed to inquire into Paddy Cultivation in Ceylon during 1930' in preference to new works."

In introducing the motion Mr. Armstrong pointed out that District Sub-Committees were appointed in 1930 to inquire into paddy cultivation and to suggest means for its improvement. Twenty Committees met at various centres in each of the nine Provinces and their reports were published. He felt that insufficient attention had been paid by Government to the findings of these Committees, especially in regard to irrigation facilities. He felt that

the attention of Government should be paid to full development and completion of existing irrigation schemes and instead of the present policy of development of new schemes.

Mudaliyar N. Wickremaratne seconded the proposal.

Mr. S. G. Taylor, speaking on behalf of the Director of Irrigation, said that the first part of the resolution was, in fact, the policy of the Irrigation Department at the present time. With regard to the second part of the motion, he pointed out that the new works being undertaken by the Department were mostly for supplementing the supply of water to existing works. Since 1932, the Department had spent two lakhs of rupees each year on village works and this work took about one-half of the time of the Department. The recommendations of the District Sub-Committees had not been laid aside but work was proceeding on them. Much had been done since the report was published but there had not yet been time to do all.

A general discussion followed.

The Chairman put Mr. Armstrong's resolution to the meeting and it was carried.

COLONIZATION WORK AND THE DEPARTMENT OF AGRICULTURE

Before proceeding with this item, the Chairman drew attention to a report that had appeared in the local press to the effect that the Ministry for Agriculture and Lands had appointed a Committee to consider the working of colonization schemes. He stated that he had, as yet, received no official intimation of this.

Mr. Montague Jayawickreme then moved—

> "That this Board is of opinion that all colonization work should be under the entire control of the Agricultural Department and that Revenue Officers should be only responsible for the allocation of lands."

In speaking to his resolution, Mr. Jayawickreme said that he felt that the Board should express to the Ministry its considered opinion of colonization policy. He felt that the supervision of colonization schemes at present was inadequate and that officers in charge had insufficient technical knowledge. The supervision of colonization should be under the control of the Agricultural Department.

Mr. S. Armstrong seconded the motion. He felt that if the present staff of the Department of Agriculture was inadequate for the purpose more staff should be provided. Mr. James P. Fernando supported the motion.

Several other members contributed to the discussion. The Chairman stated that he had received from the Land Commissioner a list of the activities which were involved in colonization schemes and pointed out that several Government departments were concerned. He felt that the revenue officer was the most suitable co-ordinating officer and not an agricultural or other technical officer.

In concluding the discussion Mr. Montague Jayawickreme said that he was still of the opinion that the Divisional Agricultural Officer should be the co-ordinating officer with, if necessary, the assistance of a revenue officer as administrative secretary.

The motion was put to the meeting and carried.

THE ERADICATION OF BUNCHY TOP DISEASE OF PLANTAINS

Mr. C. Arulambalam moved—

"That as the Bunchy Top Disease of the plantain is prevalent in all parts of the Jaffna District and as it is the cause of serious loss to the cultivators of that crop, which is one of the staple money crops next to tobacco of the Jaffna cultivator, and as it is beyond the means or the capacity of the average cultivator to eradicate the disease, the Central Board of Agriculture recommends to the Executive Committee of Agriculture and Lands to have the necessary steps taken without delay, by providing the Agricultural Department with adequate funds and staff, to enable it to carry out the work of eradicating the disease from the District through planned and co-ordinated action."

In speaking to his resolution, Mr. Arulambalam stated that bunchy top disease of plantains had been prevalent in Jaffna for about six years. It was most serious in Valigamam West Division. He referred to the bunchy top eradication work which had been undertaken within the last year or so by the Department of Agriculture but pointed out that the disease was so widespread that the work could not be tackled by a single Plant Pests Officer.

He suggested that, in order to prevent the re-infection of treated gardens, a plantain nursery should be established by Government to supply healthy suckers to cultivators.

He pointed out that the plantain-growing industry was an important one in Jaffna and stressed the need for an extension of the work now being undertaken.

Mr. A. C. Attygalle seconded the motion.

Mr. M. Park, Plant Pathologist, stated that cultivators in Ceylon had been slow to adopt the measures recommended by the Department of Agriculture for the eradication of bunchy top disease of plantains. It had therefore been decided to study the economics of large-scale eradication work in the villages with a view to determining whether it would be possible to eradicate the disease completely and, if so, at what cost. Experimental eradication campaigns were therefore started, early in 1938, in the Malay and Sinhalese colonies at Ambalantota in the Hambantota District, and in one Police Vidane's Division of Valigamam West in Jaffna. He reviewed briefly the extent and cost of these two campaigns. In Jaffna, the success of the work was mitigated by the difficulty of obtaining disease-free planting material. To overcome this difficulty, it was hoped in the next financial year to establish a plantain nursery for the supply of disease-free suckers.

He wished to emphasize the fact that the campaigns had been experimental only. A review of the results obtained was about to be made, taking into consideration the cost, the results achieved and the practicability of wide extension of the work. A full report would be submitted to the Board as soon as possible and he suggested that Mr. C. Arulambalam would perhaps be willing to defer his proposal until the report was considered by the Board.

Mr. Arulambalam accepted the suggestion made by the Plant Pathologist and the matter was deferred.

ANY OTHER BUSINESS

Tobacco Officer.

Mr. C. Arulambalam stated that he understood that a Tobacco Officer had been appointed. He inquired if the Director of Agriculture could state the lines on which this officer would work when he arrived in Ceylon.

The Director of Agriculture stated that the investigations to be undertaken could not be decided definitely until the Tobacco Officer arrived.

Bovine Tuberculosis in Cattle..

The Chairman stated that Mr. R. H. Spencer-Schrader had drawn his attention to a reference made by the Hon. the Minister of Health at a meeting of the State Council held on February 22, 1939, to the incidence of Bovine Tuberculosis among European cattle in the Nuwara Eliya District and had asked for full information.

Mr. M. Crawford, Deputy Director (Animal Husbandry) and Government Veterinary Surgeon, said that, up to 1933, there had been only 3 cases of Bovine Tuberculosis recorded during a period of 37 years. In that year, cases were recorded on two estates in Badulla District, on one estate in Nuwara Eliya District and in two places in Kandy District. The number of cases was not large but regulations to control the disease were passed which were much more stringent than in other countries. There had been recorded two cases in each of the years 1935, 1936 and 1937 and none since. Figures obtained from the Colombo slaughter-houses, which dealt with one-third of the animals slaughtered in Ceylon, showed that there had not been a single case of bovine tuberculosis among the 148,000 animals inspected during the last five years. He felt that this record was unexcelled in any other part of the world.

Mr. Spencer-Schrader expressed his thanks for the information.

The Chairman, in conclusion, stated that the State Council had recently given a great stimulus to animal husbandry in Ceylon by voting a large sum of money for the purchase of cattle. It was hoped to import a large number of cattle from India shortly.

The meeting terminated at 5.20 P.M.

MALCOLM PARK,
Secretary, Central Board of Agriculture.

Peradeniya, April 12, 1939.

COCONUT RESEARCH SCHEME

BOARD OF MANAGEMENT

MINUTES OF THE FORTY-FIFTH MEETING OF THE BOARD OF MANAGEMENT, COCONUT RESEARCH SCHEME, HELD IN ROOM NO. 202, NEW SECRETARIAT, COLOMBO, ON WEDNESDAY, APRIL 19, 1939, AT 10.30 A.M.

Present.—Mr. E. Rodrigo, C.C.S., Acting Director of Agriculture (in the Chair); Mr. C. H. Collins, C.C.S., (Treasury Representative); Mr. O. B. M. Cheyne; Mr. James P. Fernando; Mr. H. W. Peiris; Mr. G. Pandittesekere, J.P., U.P.M.

Dr. R. Child, Director of Research, acted as Secretary.

Apologies for absence were received from Mr. A. Ekanayake, Mr. D. D. Karunaratne, J.P., Mr. L. J. M. Peiris, Mr. S. Samarakkody, M.S.C., and Mr. E. R. Tambimuttu, M.S.C.

MINUTES

The minutes of the previous meeting held on Friday, October 14, 1938 which had been circulated to members were confirmed.

BOARD OF MANAGEMENT

The Chairman reported that Mr. O. B. M. Cheyne had returned to the Island on October 16, 1938, and resumed his seat on the Board.

The Chairman reported two new nominations from the Low-Country Products Association. Mr. H. W. Peiris had been nominated in November, 1938, in place of Mr. Wace de Niese, who had served three years on the Board. Mr. James P. Fernando had succeeded Mr. Tyagarajah as Chairman of the Low-Country Products Association from March 15, 1939, and so became an *ex officio* member of the Board.

The Chairman welcomed Mr. H. W. Peiris and Mr. James P. Fernando to the Board and expressed appreciation of the service of the former members.

STAFF

Geneticist's Agreement.—It was decided that Mr. Peiris should be re-engaged as Geneticist after the expiry of his present contract on September 30, 1939, and that the Deputy Financial Secretary should be requested to advise the Board on conditions of service and salary.

K. M. Fernando's leave.—The Chairman reported that K. M. Fernando, Laboratory Attendant, had been mobilized with the Ceylon Light Infantry during the months of February and March. The Board approved of this being regarded as leave on full pay.

Leave Conditions of Staff.—The Chairman said that he intended at the next meeting to put proposals to the Board for amending the leave conditions of the Staff particularly with respect to Government holidays.

ANNUAL REPORTS

The following reports were tabled and were approved by the Board :—

Report of the Geneticist for 1937.

Report of the Board of Management for 1938.

Report of the Auditor-General for 1938.

Report of the Director of Research on Bandirippuwa Estate for 1938.

In connection with the reports, the Chairman raised the question of their publication. He reported that the Director of Research had already sent for publication two bulletins embracing respectively the reports of the Soil Chemist and of the Geneticist for 1936 and 1937. The Board gave retrospective sanction for these publications.

After some discussion, the Board decided that besides the Administration Report published annually as a sessional paper by Government, there should be published a Bulletin containing an account of work done by the Staff in not too technical language.

Mr. S. R. K. Menon.—The Chairman reported that the draft agreement had been prepared by the lawyers and was under consideration. The details would be put to the Board in due course.

ESTATES

Bandirippuwa.—The monthly Progress Reports from October, 1938, to March, 1939, inclusive, were approved.

Ratmalagara.—The Reports from October, 1938, to March, 1939, were approved by the Board.

In connection with the Progress Reports on the Estates, the Chairman doubted whether the circulation of these reports monthly had any value commensurate with the time and labour involved in the office. The Board of Management agreed that the circulation of a half-yearly statement would suffice. The monthly statement would be prepared by the Superintendent of Estate as usual but would not be duplicated and circulated.

BUILDINGS

Circuit Bungalow and Field Lab.—It was decided that the Director of Research should obtain estimates for the construction of the Circuit Bungalow and Field Laboratory from local contractors ; refer these to the Building Committee, who would then authorize the work to proceed if they were satisfied with the estimates and specifications, reporting to the Board of Management at the next meeting.

MISCELLANEOUS

Coconut Toddy Vinegar.—The Board approved the inclusion in the Programme of Reserach for 1939, of a series of vinegar analyses, in response to a request from the Department of Industries.

Workmen's Compensation Insurance.—Following the instructions of the Board at the previous meeting, the Director had obtained particulars of the cost of insuring the Scheme's liability for its employees under the Workmen's Compensation Ordinance, No. 19 of 1934. These had been circulated and the Board of Management had agreed to the policy being taken out, which had been done.

Letter from Ceylon Coconut Board.—A letter from the Ceylon Coconut Board relating to Consumption Research was read. The Chairman explained that this letter had been received shortly after the last meeting at which the Board of Management had approved the Research Programme for 1939. It was decided to write to the Coconut Board stating that the letter was received after the programme for 1939 had been decided ; but that the contents were noted and that such items as the Board considered likely to be useful would be included in 1940 ; also that some of the items—such as vinegar—had in fact been included in 1939.

A letter from Sir Wilfred de Soysa to the Low-Country Products Association concerning Coconut or Sweet Toddy Syrup, which had been referred to the Board of Management by the representative of the L.C.P.A was next considered. The Board expressed the opinion that it was highly unlikely the coconut syrup could be prepared for an export market in competition with Fancy Molasses or Cane Syrup prepared direct from the sugar cane. It was decided to reply to this effect.

Training of Students.—In accordance with the instructions of the Board at the previous meeting, the Director of Research had, with the Chairman's approval, circulated a memorandum on the subject of training of students. The Chairman said that he agreed with the Director of Research that the provision of agricultural training would be difficult ; with regard to the suggestion in the memorandum regarding research training for post-graduate students, he was of opinion that there was not much point in training such students unless there was at least a reasonable possibility of openings for men with that training. In the case of Genetics, for example, there would obviously be no opening for a specialist on the Genetics of the Coconut Palm. Even if it were possible for such a student to study a wider sphere, opening for Plant Geneticists in Ceylon were not likely to be numerous. This argument perhaps applied with less force to Technological Chemistry.

The Board, after discussion, decided that the Chairman should inform the Hon. Minister for Agriculture and Lands that the Board of Management had discussed the question of training Research Students and considered that a beginning could be made with one or two students in the laboratory of the Technological Chemist. The Hon. Minister might then be able to advise H.E. the Governor to issue instruction to the Board of Management in terms of section 4 (*b*) of the Coconut Research Ordinance.

Coir Fibre Ribbon.—The Chairman said that the Director of Research had circulated a translation of a Dutch publication on Coir Fibre Ribbon, which might be of interest. He understood that the Department of Industries, to whom a copy had been sent, were interested in the subject.

The meeting adjourned at 12.40 P.M.

3——J. N. 84070 (5/39)

REVIEW

Scientific Horticulture.—The Journal of the Horticultural Education Association, Volume VII., 1939.—Edited by R. T. Pearl, B.Sc., A.R.C.S., D.I.C., 212 pages, 12 plates and 17 text figures. Published by the Horticultural Education Association. Copies are obtainable from the Editor, *Scientific Horticulture*, South-Eastern Agricultural College, Wye, Kent. Price 4*s*. net.

THIS volume of the journal, formerly known as *H. E. A. Year Book*, contains twenty-two articles on widely different subjects. Among the more interesting contributions are "Rootstock work at East Malling" by R. G. Hatton; "The influence of intermediate stem-pieces in double-worked apple and pear trees" and "Winter pruning trials with apples at East Malling" by N. H. Grubb; "Practical methods of frame-working fruit trees" by R. J. Garner and W. F. Walker; "Manurial experiments with apples and pears at East Malling 1919-1938" by W. A. Bane; "Plant injection for the diagnosis of mineral deficiencies" by B. F. G. Levy; "Researches into the cause and prevention of frost damage" by C. E. Cornford; "Trials of logan-berries, blackberries and hybrid berries at East Malling" by A. B. Beakbane and "Preliminary trials in growing horticultural crops in nutrient solutions" by S. R. Mullard and R. H. Stoughton. The last-mentioned article is of particular interest as the growing of plants in nutrient solutions has hitherto been confined to the laboratory and plant house. The possibility of the commercial cultivation of crops in nutrient solutions may come as a surprise to many readers.

Although some of the subjects treated have no direct bearing upon tropical crops, they will, nevertheless, be read with interest by research workers as well as by laymen concerned with tropical horticulture and the volume would prove a valuable addition to the library of those in Ceylon who are engaged in horticulture.

The illustrations are well produced and the diagrams and figures are clearly and correctly drawn.—T. H. P.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED MAY 31, 1939

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1939	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Blackquarter	1	..	1	..	..	..
	Rabies	2	..	..	..	..	2
	Rinderpest	9	..	..	2	..	7
	Piroplasmosis	2	..	..	2	..	..
Colombo Municipality	Foot-and-mouth disease	25	..	2	22	..	1
	Anthrax	1	..	1	..	..	..
	Rabies	2	1	2	..	..	..
	Piroplasmosis	5	2	..	5	..	..
Cattle Quarantine Station	Foot-and-mouth disease	2	1	..	1	1	..
	Anthrax	29	..	29	..	..	..
Central	Foot-and-mouth disease	137	54	..	84	53	..
	Anthrax	1	..	1	..	..	..
	Rabies	8	..	2	..	..	6
	Piroplasmosis	5	..	1	4	..	..
	Contagious mange	18	..	2	6	10	..
	Blackquarter	8	..	8	..	..	..
Southern	Foot-and-mouth disease	15	15	..	15	..	..
	Haemorrhagic Septicaemia	4	4	4	..	..	..
	Rabies	1	..	..	..	..	1
Northern	Foot-and-mouth disease	130	..	7	123	..	..
Eastern	Foot-and-mouth disease	2	..	..	2	..	..
North-Western	Foot-and-mouth disease	122	..	3	119	..	..
	Rabies	2	1	..	..	..	2
North-Central	Foot-and-mouth disease	1,364	57	..	1,307	57	..
Uva	Foot-and-mouth disease	90	32	4	54	32	..
Sabaragamuwa	Haemorrhagic Septicaemia	1	..	1	..	..	..

A. JAYASINGHA,
for Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

Department of Agriculture,
Peradeniya, June 19, 1939.

METEOROLOGICAL REPORT, MAY, 1939

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	86·2	—0·4	78·6	+1·2	79	89	7·7	13·03	22	— 1·95
Puttalam ..	86·9	—0·9	79·1	+0·6	80	87	7·2	3·81	5	+ 0·07
Mannar ..	86·8	—2·9	80·6	+0·1	79	85	8·5	5·23	4	+ 3·33
Jaffna ..	86·3	—1·5	81·1	—0·3	81	81	4·0	8·78	3	+ 7·13
Trincomalee ..	92·7	+1·2	79·1	+0·6	60	80	5·4	0·03	1	— 3·42
Batticaloa ..	89·9	—0·2	77·8	—0·2	72	86	4·2	0	0	— 1·89
Hambantota ..	85·1	—1·4	77·5	+0·4	84	91	5·2	4·53	8	+ 1·10
Galle ..	84·0	—0·6	78·5	+0·9	82	86	6·8	6·83	15	— 5·64
Ratnapura ..	87·8	—0·5	75·3	+0·6	76	93	6·4	23·79	19	+ 3·72
Anuradhapura ..	87·6	—2·5	76·2	—0·3	66	93	6·8	3·82	3	+ 0·69
Kurunegala ..	88·1	—0·6	76·2	+0·6	72	88	7·2	6·24	8	— 0·44
Kandy ..	85·9	—0·4	71·8	+0·9	70	85	6·1	5·49	7	— 0·50
Badulla ..	85·8	+0·7	65·3	—1·1	65	95	3·6	2·49	7	— 2·19
Diyatalawa ..	79·3	+0·7	61·6	—0·3	62	81	5·2	2·78	6	— 3·08
Hakgala ..	74·8	+1·8	59·4	+1·7	66	78	4·4	4·73	4	— 3·23
Nuwara Eliya ..	71·3	+1·0	54·6	+1·5	74	88	7·8	7·67	12	+ 0·79

The rainfall for May was below normal over the greater part of the Island. The chief districts showing excess were the Jaffna Peninsula, the ~~greater~~ part of the Northern Province, and the greater part of the west and south ~~coasts~~ and neighbouring districts, while in the south-western low country excesses and deficits were irregularly mixed together. The hill districts were generally in deficit, with a few stations reporting slight excess. The greatest excesses above normal were 12·54 inches, at Delft, and 11·88 inches, at Hanwella Group, while five stations in the north, mainly in the Jaffna Peninsula, reported excesses of 5 to 10 inches. The greatest deficits below normal were 9·20 inches, at Hiniduma, and 7·96 inches, at Morawaka.

The highest monthly totals were 29·84 inches at Hanwella Estate, 27·94 inches at Rayigama, and 27·93 inches at Carney, while six other stations, all in the south-western low country, or the lower south-west slopes of the hills, reported totals over 25 inches. A large number of stations, mainly in the eastern and north-eastern low-country, reported totals of less than 2 inches, but only a few reported no rain for the month. These were mainly in the neighbourhood of Trincomalee and Komari.

There were 190 daily falls of 5 inches or over, of which 24 were over 10 inches. The highest daily fall reported was 13·69 inches at Agalawatte, on the 6th. Of the falls over 5 inches, 75 fell on the 6th, and 108 on the 7th. These falls were mainly in the south-west of Ceylon, though there were also a few heavy falls in the north. There were also a few daily falls of 5 inches or over on the 2nd, in the districts near Galle.

The south-westerly barometric gradient which had appeared at the end of April persisted throughout May, with winds that were generally south-westerly. The rain was mainly confined to the south-west of Ceylon, and was usually only moderate in amount, except on the 6th, 7th and 8th, particularly the two former days. As a result of heavy monsoon rains in the Kelani catchment on these days, a major flood was experienced in that river. From the 21st till the end of the month, very little rain was reported anywhere in Ceylon.

Day temperatures were generally below normal, except up-country, where they were above the average. Night temperatures were on the whole a little above normal. In the low country day humidities were above normal, and night humidities about normal, while humidity was in deficit in the hills. Cloud was generally in deficit in the hills, and on the whole in slight excess elsewhere. Barometric pressure was on the whole about normal in the south-west, and in deficit in the north and east, giving a steeper mean barometric gradient than usual. Winds were above normal strength, particularly in the north and north-east, and were generally south-westerly in direction.

Hailstorms were reported on the 25th, from Holmwood Estate and Ella.

H. JAMESON,
Superintendent Observatory.

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Tropical Agriculturist

July, 1939

EDITORIAL

THE CITRUS FRUIT

THE area under citrus in this country has steadily increased during the last few years. Interest in the crop has grown and the Department of Agriculture has stimulated that interest and helped those who wished to plant citrus. It is probable that the recent rate of expansion will be maintained for some years. It is very important that the pioneers who have invested money in this nascent industry should not suffer disappointment through the absence of a market which will absorb their produce at a remunerative price. It is premature to look to a market abroad. Increased local consumption can only follow a general rise in the earning capacity of the urban and semi-urban population. The activities of the Department of Industries will no doubt produce this rise in course of time. In the meantime the citrus grower must look to the present demand for his market, and must capture as much of it as seasonal fluctuations of production allow him. About 9,000 cases of citrus fruit are annually imported, and it is a curious fact that even during the months when the local fruit is abundant the imported article finds purchasers at prices appreciably higher than the local grower can obtain for his oranges and his grapefruits. The consumer who considers fifteen cents too high a price for a local grape-fruit will often cheerfully pay thirty cents for a Californian or South African fruit.

The reason for this phenomenon merits investigation. Some aspects of the problem were examined by Dr. Joachim, the Agricultural Department's Chemist, and the results are published in this number. He admits what, in fact, all of us know, that there are certain superficial characteristics in which the imported fruit is superior. Its colour is attractive; its coat is less tight-fitting and can be more easily removed; it has less seed; and, perhaps, the rag inside is less coarse. Our inferiority in some of these characteristics is climatic in origin;

but in the case of most of them improvement can be effected by selection and culture. Work is in progress in.these directions. The essence of the comparison is in the chemical analysis. The results of the analysis are summarized in table V. of Dr. Joachim's article.

The most striking feature is the wide range of variation of all the essential factors. For example the juice content of local oranges ranges from 35·4 to 63 per cent., and that of imported oranges from 36·9 to 62·2 per cent., and their sugar-acid ratio from 5·3 to 17·3 and from 5·4 to 16·8 respectively. It will be noticed that in practically every essential characteristic the range is wider in the case of the local fruit, but only very slightly wider, so that there is nothing to choose between them with regard to uniformity of quality. Statements of averages must be read and interpreted in relation to the range of variations, and little importance can be attached to differences in the average in this analysis. But in fact the differences in the averages between the local and imported fruits are very small. Thus the average juice contents of imported oranges and local oranges are 49·9 and 45·4 per cent. respectively and the corresponding figures for grapefruit 40·1 per cent. and 43·5 per cent. It is interesting to note in parenthesis that there is no justification for the reputation which the imported grapefruit has for superior juiciness. Similarly the high vitamin contents differ only by 2·7 mgm. per 100 ml. of juice in the case of oranges and by 2·9 in terms of the same unit in grapefruit. These are only slight arithmetical differences with no scientific significance whatever, and the lay mind appreciates Dr. Joachim's argument in summary that "considered as a whole, the average composition of the local samples is not significantly different from that of the imported samples".

There remains the elusive quality of flavour. The Scientist has not so far been able to invent a formula based on chemical analysis which would provide a reliable index of flavour, but the best known guide, though an imperfect guide, to flavour "is the true sugar/acid ratio, considered in conjunction with the actual amounts of sugar or acid or both present in the juice". The averages ugar/acid ratio is higher in the case of local fruit, while the total content of both acid and sugar is slightly higher in the case of the imported fruit. These slight arithmetical differences have as little significance as those relating to juice, and the Chemist's generalization regarding the similarity of local and imported fruits in respect of chemical composition is equally applicable to flavour in so far as that quality is determinable by physical tests other than the application of the human tongue.

From these considerations we draw the conclusion that this country can raise an orange and a grapefruit which is quite equal in essential food values to those of the better known fruit-growing countries of the world, while it has much ground to cover in respect of the qualities which are related to what may be called the aesthetics of food.

4

THE TEA PLANT IN INDUSTRY: SOME GENERAL PRINCIPLES

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P. K. BARUA.

THE tea plant was originally classified as *Thea* but was later considered by some botanists not to differ sufficiently from those characters already defined as *Camellia*. At an international conference of botanists which was held in Holland in 1935, it was decided that the tea plant should in future be classified as *Camellia*. An international conference of horticulturists held at Paris in 1932 had already come to a similar decision. It is, in fact, now considered that there is no valid distinction between the characters which have been used to define a plant as a *Thea* and those used to define a plant as a *Camellia*. The tea plant may satisfactorily be called *Camellia Thea* Link. The term " Link " refers to a preserved specimen and to a description—in unmistakable scientific terminology—of the plant recognised by the German naturalist Link as *Camellia Thea*: the word " Link " is not part of the plant name but is a reference for the purpose of comparison and its employment is a precaution against confusion. Quotation of the botanist's name (usually given in an abbreviated form) is necessary for strict accuracy because, through ignorance of what botanists in other countries are doing, the fault has often been made of giving a slightly different classification (and hence coining a different name) for the same, or variable forms of the same plant. This does not matter much if all botanists have a revision of their classification from time to time, *i.e.*, if they put their files in order : anyone used to working in a large office knows that the classification of files has to be revised from time to time as more material and knowledge accumulate ; also, very frequently the first classification is a temporary one and different clerks may not be unanimous about this. The fault of one plant being classified slightly differently in different places would be of importance only if the discrepancy persisted for such a length of time that two names for one plant came into general usage. Such discordance is not very likely

to occur nowadays and would not persist for long with more rapid means of communication and a more general diffusion of knowledge. The classification of plants is to-day an international affair and frequent references on doubtful points are made between different countries. It is unfortunate that several names for the tea plant have already come into use. According to Fischer, writing in the *Journal of the Bombay Natural History Society* (No. 4., 1937), "it was pointed out at the 1935 Congress at Amsterdam that botanists engaged in economic studies have neither the time nor the facilities for keeping abreast with nomenclatural research. This difficulty was admitted by the Congress. Accordingly, it was resolved to draw up a list of the important economic and horticultural plants named in accordance with the International Rules, which list shall remain in force for the usage of such applied botanists for a period of ten years. A special Committee was appointed to consider all those species for which claim for inclusion has been put forward and it is hoped that the list will be ready for publication before long." The tea industry's botanists in Java, Ceylon, and India have, with the support of their respective Directors, jointly approached the special Committee appointed by the 1935 Congress with a request that the nomenclature of the tea plant be considered by the Committee. This request was forwarded by Dr. Tubbs of Ceylon through Sir Arthur Hill, the director of Kew Gardens. It is possible that the name for the tea plant will again be revised—but this time with approved international authority; pending the report of the Committee, the tea industry botanists in N.E. India, S. India and in Ceylon have decided to use the name *Camellia Thea* Link. whilst it seems that Java prefers the term *Thea sinensis* Linn. given to the tea plant by Linnaeus in 1753. It will be seen that either term is perfectly satisfactory provided that the appropriate reference Link or Linn.—the latter short for Linnaeus—is given. Recent English usage has favoured *Camellia Thea* Link. The tea plant is sometimes referred to as *Camellia sinensis*, this term utilizing the specific name given to the plant by Linnaeus in 1753 and re-classifying the plant as a *Camellia* in accordance with current ideas. Russian botanists favour *C. sinensis* which, according to Sealy writing in the *Journal of the Royal Horticultural Society* for August, 1937, is the correct name now that the genus *Thea* is merged in *Camellia :* for technical literature this name would at times need to be written "*Camellia sinensis* (L.) O. Kuntz" thus giving reference to the authority for the union of the old name with the new genus. *C. sinensis* is sometimes written *C. chinensis*—this is a difference of spelling, the former method being more commonly used. Eleven different names are to be found in botanical literature referring to various plants all of which are now

regarded as belonging to the one species *Camellia Thea* Link: of these terms Masters' *Thea assamica* and Griffiths' *Camellia theifera* are commonly met with.

The tea plant has been cultivated in England since 1768 and the genus *Camellia* has long been known to gardeners: several species are in cultivation, *Camellia japonica* Linn. being a familiar example. Another species of wide geographical distribution, *Camellia drupifera* Lour. occurs in the Naga and the Khasi Hills and is used in one hill village for the manufacture of tea. Watt considers it probable that the Burmese at one time used *C. drupifera* for the manufacture of "letpet" tea, a kind of pickle popular with the Burmese and Shans and now made from the true tea plant: according to Watt "letpet" is the vernacular name of *C. drupifera.* The seeds of *C. drupifera* contain appreciable quantities of oil (Seeman. 1859. p. 344) as also do those of *C. oleifera* Abel: "this latter species is indigenous to China, where it is widely cultivated for the seeds from which an oil is obtained" (Sealy. 1937. p. 361)—this oil is presumably the half mythical "tea seed oil" referred to at times in literature dealing with the tea industry. An oil known to commerce as "tea tree oil" and valuable for its disinfectant properties comes from *Melaleuca alternifolia,* an Australian plant related to eucalyptus. Several genera closely related to *Camellia* occur wild in India: an example of the genus *Pyrenaria*—*Pyrenaria barringtoniaefolia* Seem.—found its way in small quantities into one Assam tea garden and, because of its superficial similarity to tea, for a long time remained undetected: the presence of this plant was found to be detrimental. *Pyrenaria* has been confounded by botanists with the tea plant: a plant considered by Prof. Choisy in 1855 to be a *Thea* allied to the wild tea of Assam is now regarded as a *Pyrenaria* (*P. attenuata* Seem.). A *Schima*—*Schima Wallichi* Chois.—is common in N.E. India and is known in the Dooars and Darjeeling as *Chilauni* (Chalouni Tea Estate in the Dooars taking its name from the previous abundance of this tree) and in Assam as *Bher Gos.* Attempts at Tocklai to cross *Schima* and *Pyrenaria* with tea have failed. Crosses of tea with other *Camellias,* as *C. drupifera,* are more likely to succeed; some of these related species—particularly those native to Assam and Bengal—might also make suitable rootstocks on which to bud or graft selected types of tea.

The chromosome content of the tea plant has recently been established by Subba Rao of the United Planters Association of South India as 30, thus confirming the earlier work of Dutch and, more particularly, Russian and Japanese investigators. Subba Rao found that the chromosome number of 30 also applies to a China type.

The tea plant shows an appreciable degree of self-sterility and invariably sets a better crop of seed with pollen from another bush : considering any seed bearer it is always possible to find one source of pollen (*i.e.*, one other bush) which, if this alone is caused to fertilize the flowers of the seed bearer, will result in an outstandingly good crop of seed : use of the best pollinator will result, on an average, in twice as much seed as that to be set with equal supplies of pollen from every bush in the neighbourhood, and in particular cases nearly four times the crop has been obtained. The average crop of seed set by a tea bush with its own pollen alone is about one quarter of that which would be set if the flowers are able also to receive adequate supplies of pollen from numerous other bushes; though in particular cases both greater and lesser success might be expected from self-pollination. Russian botanists found that the plants resulting from self-pollination were inferior in vigour to those resulting from cross-pollination, besides which the self-fertilized seed showed a marked reduction in germinating capacity. Insects, such as bees and wasps, will carry pollen from bush to bush, but as the tea plant in the plains of N.E. India flowers at a time of lessened insect activity and at a time when bees probably migrate to the hills, it seems likely that the cross transfer of pollen by insects is not very effective and self-fertilization may sometimes occur under these conditions. With an efficient cross transfer of pollen it is unlikely that more than 3 per cent. of the total seed formed will be the result of self-fertilization—nevertheless it has been found possible for artificial self-fertilization to give as big a crop of seed as that resulting from natural pollination under conditions where it is evident that insects do not provide an efficient cross transfer of pollen. Complete cross transfer of pollen by artificial means has been shown to result in 13 per cent. of the flowers setting seed thus giving a seed crop six times that estimated, on inadequate data, to be usual in a bari* under Upper Assam conditions. Wellensick, in Java, obtained germinated seed totalling 12 per cent. of the number of flowers artificially pollinated as against a similar figure of 8 per cent. for flowers pollinated naturally. Expressed on the same basis as that used by Wellensick, the Tocklai result, quoted above, of 13 per cent. successful pollinations gives a total seed germination of 17 per cent. of the number of flowers pollinated. In Russia, Bakhtaj estimates that only 2 per cent. of the flowers normally form seed.

The conclusion that tea must, in nature, be almost entirely cross-fertilized accounts for the extreme variability of the seed

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*The term "bari" applies to an enclosure, *e.g.*, "seed bari" means a seed garden.

available on the market: the seed sold by any one concern is mixed so that in some cases there is little difference between populations of plants raised from two or more sources of supply: in some cases distinctive strains characterize a particular source of supply. Seed is sold on the market under various trade names as Khelmati, Kukilamukh, Sibsagar, &c., which are generally derived from place names of the locality where a particular dealer's seed-bearing trees are situated. These names are to be taken as indicating that the bulk progeny of a particular area of more or less variable seed-bearing trees inter-fertile amongst themselves. A point to note is that seed-selling concerns may extend their seed-bearing area either with progeny from the original area or from other sources, and may also thin out or replace supposedly undesirable trees in the original area; so that an area of tea raised from, say, Khelmati seed may differ from an area of tea raised 10 years later from seed still marketed as Khelmati: this point requires consideration when one is interpreting the result of experiments dealing with jāt differences. All tea may be broadly classified into dark and light leaf types, and seed dealers market, as far as possible, either dark-leaf or light-leaf types under a particular trade name. These trade types, as Khelmati, Kukilamukh, Sibsagar, &c., are referred to in the tea industry as *jāts*.

All the commercial types of tea and all the wild types, as Lushai and Indo-China, belonging to the one species *Camellia Thea* Link. (=*Thea sinensis* Linn.). This is very variable and the leaves of different tea bushes make tea of decidedly different quality—in some cases poor quality. As tea is largely cross-fertilized, individual variations are continued indefinitely and the only practical method of overcoming this is by some method of vegetative propagation, as in the case of the apple. The apple, like tea, does not come true from seed and each so called "variety" of apple is but one selected tree multiplied indefinitely through the process of grafting. An individual so split up that parts of it lead an independent existence in different places and in union with different rootstocks is spoken of as a clone: a clone may also be formed by rooting many cuttings from the same plant. At the moment there seems little prospect of tea clones being used for leaf production, but bushes selected because of their particularly desirable progeny may with advantage be propagated to form a clonal seed bari: in this case due consideration would also have to be paid to the propagation of a source of pollen likely to ensure the continued production of desirable progeny—in fact, the successful application of clonal selection for seed production necessitates some knowledge of the reciprocal fertility of one bush with another and this knowledge becomes the more important the less the number of bushes propagated.

The respective merits of dark- and light-leaf types under different climatic conditions are often discussed. Russian botanists have shown that dark-leaf types are, in general, much more resistant to frost than the light-leaf types: whilst non-hardy strains of dark-leaf were found, dark-leaf jāts on the whole—particularly those with small leaves—contained more hardy types than light-leaf jāts; jāts with predominating light leaf characters did not occur amongst those jāts with the highest resistance to frost. It seems possible that scientific investigation will prove the dark-leaf types of tea to be, in general, but probably with notable exceptions, more drought-resistant than the light-leaf types—or, to be more explicit, drought-resistant strains will mostly be found amongst dark-leaved tea. Individual differences in resistance to desiccating conditions seem to be as marked as those shown by any other character and there is little doubt that strains notable for resistance to the hot, dry winds of the Terai and W. Dooars could be isolated. China types are included under dark-leaf in these remarks on frost and drought resistance. In the Russian investigations seed from a Darjeeling garden gave the maximum number of frost-resistant plants and a Cachar dark-leaf seed came high in the list. Observations at Tocklai give no indication of any invariable relation between the dark or light leaf character and die-back of the branches. It is possible to find a dark-leaf stock and a light-leaf stock of which the dark-leaf shows more die-back than the light-leaf and *vice-versa*, though the question remains open as to whether die-back is more commonly associated with the one type of leaf than the other.

It is a matter of experience that dark-leaf jāts do not give the high level of quality of a modern light-leaf: at the same time it must be remembered that some of the best modern light-leaf tea shows signs of being the result, or partly the result, of cross-fertilization between two forms not likely to have been growing together naturally: some of the earliest of the lighter leaf "indigenous" jāts, now no longer grown, were markedly deficient in quality, though general opinion indicates at least one notable exception to this statement. Dark-leaf jāts at present on the market do not give the quality of the best light-leaf but it must not be assumed that it is impossible to obtain a dark-leaf type of good quality: individual dark-leaf bushes with excellent manufacturing characteristics are to be found.

Our knowledge of quality is, unfortunately, based upon the purely subjective determinations of the tea taster: the taster's estimation of quality for experimental work has been systematized but nevertheless remains at a level of exactitude which compares very unfavourably with the methods of measurement usually employed in scientific work. There is reason to believe

that the taster's sense of quality rests upon a material basis of substances known to the chemical and physical sciences, though precisely what these substances are and where and how they occur in the tea leaf is unknown. It has been found that there is a difference in the smell of the fresh green leaf upon different bushes and it was proved that bushes, the leaves of which possessed a noticeable aroma, were quite independently selected by one taster as high quality bushes (Wight and Gilchrist 1937). This suggests that the presence in the leaf of a substance with aromatic properties was responsible for "quality" as assessed by the taster; and it would appear that "quality" and "flavour" as assessed by some tea tasters differ only in degree.

Individual dark-leaf bushes have no lesser quality than the best light-leaf bushes, but dark-leaf stock usually contains a higher percentage of low quality bushes, and hence in bulk gives lower quality: quality for quality the dark-leaf bushes generally give thinner liquors—and this would appear to be true whether we include or exclude China types from the dark-leaf class. Dark-leaf bushes (of both the Manipuri and the China type) with thin liquors have been remarked upon by the taster (in ignorance of the origin of the leaf) as desirable types and give good valuations. This statement regarding the combination of quality and strength in dark-leaf bushes is a generalization: taking particular bushes of the highest and equal levels of quality, some dark-leaf plants can be found with strength equal to the light-leaf. Summarizing the characters of dark-leaf relative to light-leaf, it is found that a population of dark-leaf bushes usually contains fewer bushes of good quality and amongst these latter there are again fewer bushes which combine strength with quality. It is evident that the dark-leaf types offer great possibilities for the plant breeder, particularly when one considers their cultural characteristics. The difference between the best and the worst of the light-leaf stocks so far examined is of interest—the "stocks" in this case are fair samples of commercial jāts. The seed garden from which one of these stocks was taken was established from seed taken from "indigenous" tea found, supposedly, wild: at the time of planting this seed garden it is doubtful if any conscious selection took place, and if it did it is equally doubtful whether the selection was of any practical utility: this jāt is regarded as being a fair representative of the original so called "indigenous" tea of Assam. The better jāt is a "modern" light-leaf of later introduction and popular to-day. It is thought that a good deal of the difference between these two jāts has very probably been brought about by consciously directed selection on the part of the modern seed grower and our comparisons of the two jāts are discussed in this light: whether

this dynamic interpretation is accepted or not, the validity of the comparison remains. Both strength and quality have improved in about the same proportion and each of these has moved upwards along about 6 per cent. of their respective scales of values as recognized by the taster. Quality and strength both commenced below their half way levels and each now stands, in the better jāt, at about 50 per cent. of their possible best. This 6 per cent. move along the scale, bringing both quality and strength up to approximately the half way mark, has meant an improvement on the previous lower level of the order of 14–15 per cent. and this improvement was worth, in 1935, an extra eight pies per pound—this was under the 1935 market conditions for Tocklai manufactures when the "indigenous" light leaf was getting Ans. 9/8·56, the more modern jāt Ans. 10/4·51 and typical dark-leaf tea Ans. 10/0·52 (valuations from data supplied by Mr. Harrison of the Chemical Laboratory). It is doubtful as to how far mass selection as now practised by the seed grower can improve the better jāt.

It is considered by the botanist that dark-leaf tea will, in general, better resist vagaries of climate, particularly when the latter occur in conjunction with the kind of financial policy somewhat inadequately described as economical. On the other hand it is unlikely that any dark-leaf seed so far offered for sale will *en masse* give quality or tip equal to a good light-leaf. On the present market, increased quality (above the desirable minimum produced by good jāts of dark or light leaf) does not give very much return in the way of increased valuations; but one must also regard tea planting as a long period investment and the demands of the European market are constantly in the direction of better quality. For the Indian market, other factors such as crop and liquors being equal, increased quality is desirable. A good light-leaf jāt will give crop, quality, and appearance when properly grown and kindly treated: certain dark-leaf jāts, whilst not giving the very best quality and appearance of the light leaf, will nevertheless give good average quality and crop and can be better than an inferior light-leaf jāt; but one of the poorer light-leaf jāts will be better under conditions of plains than unselected China types. There are, however, some grounds for believing China to be desirable in the Darjeeling district where the development of flavour is seemingly associated with China dark-leaf types growing under the peculiar local conditions. In Darjeeling the continued production of flavoury teas must of necessity outweigh most other conditions owing to the inability of many gardens there to maintain competition with other districts of importance on a basis of crop alone: one must consider whether the success of a tea in another district is sufficient criterion for its introduction in Darjeeling; at present there is a tendency to introduce

outside types and justification for this practice should be sought by the local industry. In the Bengal Dooars, conditions are so varied that it is impossible to generalize: on a given garden one Manager will make a success of light-leaf type where another Manager would fail; and the generous policy of one Company will make a financial success of light-leaf where another's more stringent methods would be useless. Quite apart from financial aspects one might draw a parallel with the way in which some gardeners can succeed with exceedingly difficult subjects; such ability is not to be entirely dissociated from individual predilections. In a district with extreme and varied climatic conditions such as the Dooars, and presuming little or no scientific attention, light-leaf types cannot in general be said to be desirable: on favourable gardens in the same district, and giving an interested Manager a free hand with manures, the cultivation of a light-leaf type is a justifiable financial venture.

The terms dark-and light-leaf are used in the preceding pages in the very broad classificatory sense in which they are understood in the industry. The planting community separately distinguish a China plant of shrubby form with small, dark leaves and classify other tea as either "dark" or "light" leaf (China "hybrids" are intermediate between China and the larger-leaved forms and often with a noticeable number of light-leaved plants). "Dark" and "light" are terms derived from the dark green and light, sometimes chlorotic, green appearance of the leaves. The terms are relative and any block of tea can be separated into darker and lighter forms. An increasing percentage of darker forms corresponds with an increasing expression of several other attributes recognized by Russian botanists as *Northern* characteristics. The correspondence of dark leaf with northern attributes is not perfect and colour of the leaf alone enables one to recognize at the most three classes of plant—"dark," "intermediate," and "light"—which are not always completely consistent as to their other characteristics: consideration of several attributes of the plant enables more classes to be recognized. In this article "dark" and "light" refer mainly to trend of type (the common usage) and may be taken as indicating a broad correspondence with more northern and more southern forms as recognized by Russian botanists. The China types of the Indian planter are to be included in the extreme northern forms.

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The following sources of information have been drawn upon in completing this article; results obtained by the Botanical Laboratory staff have also been incorporated into the text previous to publication of technical data.

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THE COMPOSITION OF LOCAL AND IMPORTED CITRUS FRUIT

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THE average number of cases of citrus fruit imported annually into Ceylon between 1932 and 1938 was 9,030, the record being 13,581 in 1935 since when there has been a decline. There is likely to be a further decline in the future owing to the restriction which has been placed upon the import into Ceylon of fruit from countries affected by the Mediterranean fruit fly. On the other hand, during the period under review there has been a steady and appreciable increase in the acreage under the crop in the Island, an increase which appears to show promise of being maintained. As a result, production will, in due course, reach the point when the Island's entire requirements of citrus fruit for several months in the year can be met. The question has therefore been raised as to how the quality of locally-grown citrus compares with that of imported fruit. Quality in citrus is determined by such factors as abundance and flavour of juice, texture of pulp, thickness of rind, facility of peeling, seedlessness, amount and character of rag. Inasmuch as the flavour of the fruit is governed to a large degree by its chemical composition, it was considered that analyses of representative samples of local and imported citrus fruit would furnish useful comparative data on the point at issue. Accordingly, analyses have been made during the past twelve months of 62 samples of imported and local oranges and grapefruit, and though the samples examined were not, in the case of every sample group, as numerous as was desirable they were considered to be adequate for the purposes of this inquiry.

The samples comprised the following :—

Local oranges	15
Imported oranges	23
Local grapefruit	17
Imported grapefruit	7

The countries of origin of the imported samples were South Australia, California, South Africa, and Rhodesia. No samples of fruit were available from countries from which the importation of citrus fruit is prohibited. Samples of imported grapefruit were difficult to obtain, presumably because of the non-importation of fruit from the latter countries. The imported orange samples were of the Navel and Valencia varieties and the imported grapefruit mainly of the Marsh's Seedless variety. The local orange samples were good quality fruit of the Kotte, Valencia, Washington Navel and Indian types. Some samples were from seedling trees, others from grafts. The local grapefruit samples included the following varieties :—Marsh's Seedless, Cecily Seedless, Walters, McCarty, Triumph, Fosters and Ellen. All the local samples of oranges and grapefruit were obtained from the Government Experiment Stations or from private growers.

METHODS OF ANALYSIS.

On receipt, each sample, which consisted of 6 to 8 fruits in the case of oranges and 3 to 4 fruits in the case of grapefruit, was examined for the following characteristics :— Size and weight of fruit, colour and thickness of rind, degree of seediness, colour and flavour of pulp, character of rag and percentage by weight of juice in the fruit. The following analytical determinations of the strained juice, which was extracted with a Sunkist extractor, were carried out by the methods specified, except in regard to sugars which were omitted in certain samples :—

Total solids (*Brix*).—These were determined by the Brix hydrometer, corrections for temperature being made from de Villiers' table (17), and also by the Zeiss refractometer fitted with a sugar scale.

Acidity was calculated as citric acid with one molecule of water and in ml. of deci-normal caustic soda required to neutralize 10 ml. of juice.

Sugars.—Total and reducing sugars were determined by Lane and Eynon's method with methylene blue as internal indicator.

Vitamin C.—The recent improved iodine method of the California Fruit Growers Exchange was adopted for the estimation of vitamin C (21).

pH.—The quinhydrone method was used.

CITRUS MATURITY STANDARDS

In most citrus-growing countries, regulations are in force to prevent the export of citrus fruit, particularly oranges, unless they attain a minimum "maturity" standard. The standard commonly in use is based on the total soluble solids/acid ratio of the juice, and is frequently, though incorrectly, designated the sugar/acid ratio, since sugars are the most important of the soluble solids. In these calculations the acidity is reckoned as citric acid. The ratio varies in the different countries with the species of fruit and occasionally with the variety or other factor. Thus in California and Florida, all oranges for export should have a minimum maturity ratio of 8 to 1 (19, 20)*. In South Africa (18) the ratio varies according to the variety, being 5·5 for seedling oranges, 6·0 for Valencias and 6·5 for Navels. But fruit for export should, in addition, contain at least 45 per cent. juice by weight. The Palestine regulations demand a minimum sugar/acid ratio of 7 to 1 (15). In New South Wales (16), maturity is expressed in terms of titratable acidity. Navel oranges are considered "mature" when less than 23 ml. of deci-normal caustic soda are required to neutralize the acidity in 10 ml. of juice. In Jamaica (6), the corresponding maturity maximum suggested is 20 ml. The export regulations in regard to grapefruit are less explicit. Thus the Palestine regulations state that "no grapefruit shall be exported from Palestine unless the fruits have reached an adequate state of maturity". The reason why no rigid standards have been prescribed for grapefruit are : (1) the solid/acid ratios for fruit of satisfactory flavour and quality have been found to vary appreciably with the district of origin. In California and Arizona they range from 5·5 to 6·8, and in Jamaica from 7·3 to 11·3 (6) ; (2) the ratios are dependent on the total solid contents of the juices, being generally the lower, the higher the latter. Suitable ratios suggested for grapefruit (6) are 5·5 to 6·5 .

While the total solid/acid ratios afford a fairly reliable indication of maturity in oranges, they have certain limitations as indexes of flavour. Thus two oranges may have identical maturity ratios but distinct flavours owing to the actual quantities of sugar and acid in the juices being markedly different. A juice with a low concentration of these constituents would tend to be insipid. A better guide to flavour is the true sugar/acid ratio, considered in conjunction with the actual amounts of sugar or acid or both present in the juice. Tentative formulae (6, 22) have been suggested for calculating from the chemical data indexes of flavour, but these are not generally applicable to all varieties of citrus fruit,

* Numbers relate to references on pages 19 and 20.

nor to all countries, and soil and climatic conditions. In the analytical tables which follow, both the total solids/acid and the sugar/acid ratios for the samples examined are furnished.

RESULTS AND DISCUSSION OF DATA

The results of the examination and analysis of the samples are presented in four tables. I. and II. show certain characteristics of, and analytical figures for, local orange and grapefruit samples, and III. and IV. the corresponding data for the imported samples. In these tables the samples are classified, where possible, into sub-groups according to variety, country of origin and nature of parent tree, *i.e.*, whether graft or seedling. When discussing the data, comment will only be made on any sub-group comprising at least six samples. In table V. the analytical data of the samples examined are summarized, while in table VI. the corresponding data, obtained from the literature, for citrus fruit of various countries, are furnished.

(For Tables I. and II. see pages 21 and 22.)

ORANGES

An examination of the tables I. and II. indicates that:

(1) There are considerable variations in the analytical composition of different samples of both imported and local oranges. A wide range of variation will be apparent (*cf.* table V.) in the case of every constituent determined. To take a few examples. In regard to juice percentage, the range for local fruit is 35·4 to 63·0 and for imported fruit 36·9 to 62·2; for total solids the corresponding ranges are 8·2 to 12·7 and 9·2 to 11·9. The range is widest with the solids/acid and sugar/acid ratios, and narrowest in the case of the pH values. The flavour also varies from sweet to sour through mildly sweet, mildy tart and tart.

(2) Considered as a whole, the average composition of the local samples is not significantly different from that of the imported samples.

(3) The lowest solids/acid ratio in the case of the local samples is 8·3, a figure which is higher than the standard set for Californian fruit. All the local samples examined are, therefore, from the standpoint of maturity, up to export standard. Of the imported samples, only one has a ratio less than 8, but even this, from Rhodesia, would pass the standard adopted in its country of origin, *viz.*, 6·5. All the samples are well above the New South Wales standard.

(4) The average vitamin contents of both imported and local oranges are quite high, being respectively 52·3 and 49·6 mgm. per 100 ml. of juice.

(5) There is no appreciable difference in the average analytical composition of local fruit from grafted and seedling trees. Of imported fruit, Navels are significantly superior to the Valencias in vitamin C content.

(6) There is a fairly close correspondence between the total solids/acid and sugar/acid ratios and flavour ; but this is more noticeable when the data for any particular sub-group are compared.

(For Tables III. and IV. see page 23.)

GRAPEFRUIT

A study of the data of tables III. and IV. shows that :

(1) As with oranges, though to a lesser degree, there is an appreciable variation in the composition of individual samples of both local and imported grapefruit. Thus the juice percentages and total solids/acid ratios vary from 30·5 to 55·2 and 4·6 to 8·9 respectively in the case of the local fruit, and from 32·5 to 45·3 and 4·4 to 9·5 with the imported fruit.

(2) The average vitamin C values, sugar contents and maturity ratios of both the imported and local grapefruit samples are lower, and the acidities higher than the corresponding figures for the orange samples.

(3) The local samples, on the average, are not significantly different to the imported samples in analytical composition.

(4) There is no significant difference between the average analytical composition of the Marsh's Seedless samples and that of the other varieties, grouped together.

(For Tables V. and VI. see page 24.)

GENERAL DISCUSSION

On examining the data of table VI. which shows the analyses of representative samples of oranges and grapefruit of various countries, it will be found that the local samples of oranges and grapefruit compare very favourably in analytical composition with the fruit grown elsewhere. The general conclusions arrived at from a comparison of the analyses of local and imported citrus fruit are thus confirmed. In other respects, however, there are striking differences between local and imported oranges. Many of the local orange samples are inferior to the imported fruit in such characteristics as colour and looseness of rind, facility of peeling, character of rag, seedlessness, &c. Artificial colouration by means of ethylene does not often produce the typical colour in local oranges. These defects are probably the effects of the warm, continuously-humid climate, and are less marked in local fruit grown in the

cooler dry districts, *e.g.*, Welimada. Most samples of local grapefruit, on the other hand, are in every respect of the standard of, and some even superior to, the fruit imported into the Island. When the colour is lacking, artificial colouration can easily be resorted to with excellent results.

SUMMARY

The analyses of 62 samples of local and imported grapefruit and oranges have indicated that locally grown oranges of good quality compare favourably with imported fruit in analytical composition. Many of the local samples are, probably because of climatic conditions, inferior to imported fruit in such characteristics as colour, thickness of rind, facility of peeling, character of rag, seedlessness, &c. Most samples of local grapefruit, on the other hand, are in every respect equal, and in some cases superior, to imported fruit. Local citrus fruits have a very similar composition to fruit grown in other countries.

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TABLE I.

Local Oranges

Locality	Variety	Flavour	Seediness	Juice Per cent.	Total solids gm. per 100 ml.	Acidity: Gm. citric acid per 100. ml.	Acidity: Ml. N/10 soda per 100 ml.	Total solids/acid ratio	Reducing sugars gm. per 100 ml.	Sucrose gm. per 100 ml.	Total sugars gm. per 100 ml.	Vitamin C mgm. per 100 ml.	pH	Sugar/acid ratio
					Grafted									
Hewaheta	Navel	Sweet	Seedless	47·0	11·8	0·47	6·7	25·1	3·76	4·37	8·13	47·6	4·3	17·3
Welimada	do.	Mildy tart	Few seeds	40·1	9·9	0·62	8·9	15·9	2·86	3·78	7·67	56·0	4·3	12·4
Haputale	do.	do.	Seedless	40·3	9·3	0·67	9·5	13·9	2·88	4·04	6·92	54·2	4·4	10·3
Bibile	do	do.	do.	44·2	11·8	0·93	13·3	12·6	2·85	4·86	7·71	50·8	4·4	8·3
Average				*42·9*	*10·7*	*0·67*	*9·6*	*16·9*	*3·34*	*4·26*	*7·61*	*52·2*	*4·4*	*12·1*
Maha Illupalama	Valencia	Mildly tart	Few seeds	52·1	9·6	0·69	9·9	13·9	—	—	—	40·4	4·0	—
Mundel	Indian	Sweet	do.	39·5	13·4	0·57	8·1	23·6	2·28	5·10	7·35	54·0	4·1	12·9
Average (grafted)				*43·9*	*11·0*	*0·66*	*9·4*	*17·5*	*3·13*	*4·44*	*7·54*	*50·5*	*4·3*	*12·9*
					Seedling									
S. K. East	Kotte type	Mildly tart	Few seeds	54·4	8·2	0·90	12·8	9·1	—	—	—	42·0	3·8	—
Kotugoda	do.	do.	do.	63·0	8·9	0·98	14·1	9·0	—	—		42·2	—	—
Kotte	do.	Tart	Many seeds	48·1	12·7	1·32	18·9	9·6	4·13	3·58	7·71	51·3	3·7	5·8
Nathandiya	do.	Sweet	do.	40·0	12·2	0·92	13·2	13·3	3·61	5·23	8·84	59·6	4·0	9·6
Average				*51·4*	*10·5*	*1·03*	*14·8*	*10·2*	*3·87*	*4·40*	*8·28*	*48·8*	*3·8*	*7·7*
Matugama	Valencia type	Tart	Few seeds	53·2	9·3	1·13	16·1	8·3	2·27	3·68	5·95	36·6	3·8	5·3
Puttalam	do.	Mildly tart	Many seeds	35·4	12·8	0·53	7·5	24·4	—	—	—	59·7	—	—
Teldeniya	do.	Sweet	Few seeds	37·5	9·4	0·55	7·8	17·2	1·93	3·61	5·54	40·8	4·1	10·1
Tinnevelley	do.	do.	do.	49·7	10·9	0·60	18·5	18·1	2·41	4·80	7·21	47·0	4·1	12·0
Vavuniya	do.	Mildly tart	do.	42·5	10·3	0·77	10·9	13·5	2·49	4·55	7·04	62·2	4·2	9·1
Average				*45·7*	*10·5*	*0·72*	*10·2*	*16·3*	*2·25*	*4·16*	*6·44*	*49·3*	*4·1*	*9·1*
Average (seedling)				*47·1*	*10·5*	*0·86*	*12·9*	*13·6*	*2·81*	*4·27*	*7·05*	*49·0*	*4·0*	*8·7*
General average				***45·4***	***10·7***	***0·79***	***11·1***	***15·7***	***2·95***	***4·32***	***7·28***	***49·6***	***4·1***	***10·3***

TABLE II.

Imported Oranges

Country of Origin	Variety	Flavour	Seediness	Juice Per cent.	Total solids gm. per 100 ml.	Acidity: Gm. citric acid per 100 ml.	Acidity: Ml. N/10 soda per 10 ml.	Total solids/ acid Ratio	Reducing sugars gm. per 100 ml.	Sucrose gm. per 100 ml.	Total Sugars gm. per 100 ml.	Vitamin C mgm. per 100 ml.	pH	Sugar/ acid Ratio
South Australia	Navel	Mildly tart	Seedless	36·9	10·9	0·98	11·0	11·1	3·61	3.01	6·62	53·8	3·9	6·8
Do.	do.	Sweet	do.	50·2	10·7	0·78	14·1	13·8	—	—	—	57·0	3·6	—
Do.	do.	Mildly sweet	do.	43·1	10·9	0·61	8·8	17·8	4·05	4·26	8·31	52·5	3·5	13·6
Average				*43·4*	*10·8*	*0·79*	*11·3*	*14·2*	*3·83*	*3·64*	*7·47*	*54·4*	*3·7*	—
South Africa	Navel	Mildly tart	Seedless	50·9	11·2	0·97	13·9	11·5	4·31	3·78	8·09	57·1	4·4	8·3
Do.	do.	Tart	do.	49·3	11·6	0·88	12·5	13·3	—	—	—	53·3	3·9	—
Average				*50·1*	*11·4*	*0·93*	*13·2*	*12·4*	*4·31*	*3·78*	*8·09*	*55·2*	*4·0*	*9·6*
California	Navel	Mildly tart	Seedless	47·8	11·7	0·96	14·1	11·9	4·31	3·89	8·20	58·8	4·0	8·5
Rhodesia	do.	Sour	do.	50·9	9·2	1·25	17·8	7·4	4·14	2·60	6·78	64·6	3·6	5·4
Average (Navel)				*47·0*	*10·9*	*0·92*	*13·2*	*12·4*	*4·08*	*3·51*	*7·60*	*56·7*	*3·8*	*8·5*
South Australia	Valencia	Tart	Few seeds	50·4	9·8	0·93	13·3	10·5	2·65	3·05	5·70	53·6	3·7	6·1
Do.	do.	Mildly tart	do.	55·4	11·7	0·83	11·8	14·0	4·07	2·56	6·63	53·3	3·9	8·0
Do.	do.	Mildly sweet	Seedless	59·2	11·9	0·71	10·9	16·7	2·70	6·71	9·41	42·0	3·9	13·3
Do.	do.	Sweet	do.	52·6	10·9	0·59	8·4	17·5	1·83	3·81	5·64	34·8	4·0	9·6
Do.	do.	Mildly tart	Many seeds	47·2	10·7	0·77	10·9	14·0	3·68	3·14	6·82	47·2	4·0	8·9
Average				*53·0*	*11·0*	*0·77*	*11·1*	*14·5*	*2·99*	*3·85*	*6·84*	*46·2*	*3·9*	*9·2*
California	Valencia	Mildly tart	Seedless	48·6	11·0	0·91	13·0	12·1	2·68	5·05	7·73	60·2	3·9	8·5
Do.	do.	Mildly sweet	do.	49·5	10·7	0·97	13·9	11·0	2·16	6·18	8·34	43·6	3·8	8·6
Do.	do.	Mildly tart	do.	47·1	11·7	1·02	14·6	11·5	4·81	3·53	8·34	66·2	4·0	8·2
Do.	do.	do.	do.	46·9	10·7	0·90	11·9	11·9	4·31	3·09	7·40	56·1	4·0	8·2
Do.	do.	Mildly sweet	Few seeds	62·2	10·9	0·55	7·8	19·9	4·29	4·94	9·23	35·0	4·0	16·8
Average				*50·9*	*11·0*	*0·87*	*12·2*	*13·3*	*3·65*	*4·56*	*8·21*	*52·2*	*3·9*	*10·1*
Average (Valencia)				*51·9*	*11·0*	*0·82*	*11·7*	*13·9*	*3·32*	*4·21*	*7·52*	*49·2*	*3·9*	*9·6*
General average				***49·9***	***10·9***	***0·86***	***12·3***	***13·3***	***3·57***	***3·97***	***7·42***	***52·3***	***3·9***	***9·3***

TABLE III.

Local Grapefruit.

Locality	Variety	Juice Per cent.	Total solids gm. per 100 ml.	Acidity: Gm. citric acid per 100 ml.	Acidity: Ml. N/10 soda per 10 ml.	Total solids/ acid Ratio	Reducing sugars gm. per 100 ml.	Sucrose gm. per 100 ml.	Total Sugars gm. per 100 ml.	Vitamin C mgm. per 100 ml.	pH	Sugar/ acid Ratio
Maha Illupalama	Marsh's Seedless	47·7	8·1	1·07	14·41	8·1	3·20	4·28	7·48	44·2	3·4	7·0
Mundel	do.	46·5	9·0	1·11	15·8	8·1	3·45	2·11	5·56	44·1	3·7	5·0
Talangama	do.	46·2	8·4	1·32	18·9	6·4	3·72	2·47	6·19	39·8	—	4·7
Do.	do.	51·7	7·0	1·37	19·5	5·1	3·36	1·92	5·28	34·1	—	3·9
Do.	do.	52·7	7·4	1·29	18·4	5·7	3·49	2·10	5·59	39·0	—	4·3
Bibile	do.	30·9	8·8	1·30	21·4	5·9	2·23	2·03	4·26	39·2	3·8	2·8
Do.	do.	38·1	8·1	1·77	25·3	4·6	2·08	2·11	4·19	42·0	3·3	2·4
Nalanda	do.	33·1	9·4	1·87	26·7	5·0	4·00	1·71	5·71	45·8	3·3	3·1
Do.	do.	55·2	8·4	1·83	26·1	4·6	3·18	2·19	5·37	37·2	3·4	2·9
Dambulla	do.	40·9	8·6	1·17	16·7	7·6	3·74	2·69	6·43	43·6	3·5	5·5
Minneriya	do.	41·3	8.5	1·11	15·7	7·6	2·89	2·36	5·25	33·6	3·6	4·7
Haputale	do.	36·7	9·1	1·94	27·7	4·7	2·92	1·97	4·89	42·9	3·5	2·5
Welimada	do.	35·4	9·6	1·87	26·7	5·1	3·32	1·70	5·02	49·0	3·5	2·7
Average (Marsh's Seedless)		*42·8*	*8·5*	*1·48*	*21·0*	*6·0*	*3·20*	*2·28*	*5·48*	*41·1*	*3·5*	*4·0*
Mundel	Cecily	45·9	8·4	1·09	15·5	7·7	—	—	—	38·2	3·5	—
Do.	do.	46·5	7·0	1·15	16·5	6·1	—	—	—	40·8	3·8	—
Do.	Ellen	41·7	8·2	0·92	13·1	8·9	—	—	—	38·5	3·9	—
Bibile	McCarty	41·6	8·6	1·40	20·0	6·1	2·77	2·24	5·01	35·7	3·7	3·6
Mundel	Foster's	45·1	8·4	1·20	17·1	7·0	2·29	2·60	4·89	36·7	3·6	4·1
Minneriya	Triumph	50·3	8·3	1·09	15·1	7·6	3·47	1·43	4·90	33·3	3·9	4·5
Matugama	Walters	43·5	9·4	1·39	19·9	6·8	2·50	2·67	5·17	38·5	3·8	3·7
Mundel	do.	51·5	8·8	1·13	16·0	7·8	—	—	—	37·0	3·5	—
Peradeniya	do.	30·5	10·7	1·94	27·9	5·5	—	—	—	38·4	3·3	—
Do.	do.	46·6	9·1	1·44	17·5	6·3	—	—	—	42·2	4·0	—
Average (other varieties)		*44·3*	*8·7*	*1·28*	*17·9*	*7·0*	*2·76*	*2·24*	*4·99*	*37·9*	*3·7*	*4·0*
General average		***43·5***	***8·6***	***1·39***	***19·6***	***6·5***	***2·92***	***2·14***	***5·07***	***39·6***	***3·6***	***4·0***

TABLE IV.

Imported Grapefruit.

Country of Origin	Seediness	Juice Per cent.	Total solids gm. per 100 ml.	Acidity: Gm. citric acid per 100 ml.	Acidity: Ml. N/10 soda per 10 ml.	Total solids/ acid Ratio	Reducing sugars gm. per 100 ml.	Sucrose gm. per 100 ml.	Total Sugars gm. per 100 ml.	Vitamin C mgm. per 100 ml.	pH	Sugar/ acid Ratio
South Australia	Few Seeds	43·0	9·4	1·32	18·9	4·8	4·58	1·23	5·81	39·8	3·4	4·4
Do	Seedless	34·2	8·2	1·74	24·9	7·1	2·51	1·37	3·88	37·1	3·3	2·2
Do.	do.	32·3	9·2	1·56	22·3	4·7	3·50	1·15	4·65	34·6	3·5	3·0
Do.	do.	40·1	11·3	2·56	37·4	4·4	2·73	3·53	6·26	42·2	3·5	2·4
Average (S. Australia)		*37·4*	*9·5*	*1·79*	*26·0*	*5·2*	*3·33*	*1·82*	*5·15*	*38·4*	*3·4*	*3·0*
South Africa	Many seeds	41·3	8·6	1·79	25·7	4·8	2·39	2·03	4·42	40·8	3·4	2·5
California	Seedless	45·3	11·2	1·18	16·9	9·5	4·11	3·16	7·27	31·3	3·4	6·2
Do.	do.	44·0	9·6	1·30	18·5	7·4	3·50	1·82	5·32	30·9	3·5	4·1
Average (California)		*44·7*	*10·4*	*1·24*	*17·7*	*8·5*	*3·81*	*2·49*	*6·30*	*31·1*	*3·5*	*5·2*
General average		***40·1***	***9·6***	***1·63***	***23·5***	***6·1***	***3·33***	***2·04***	***5·37***	***36·7***	***3·4***	***3·5***

TABLE V.

The Composition of Citrus Fruit

	Oranges: Local (15) Range	Oranges: Local (15) Average	Oranges: Imported (17) Range	Oranges: Imported (17) Average	Grapefruit: Local (23) Range	Grapefruit: Local (23) Average	Grapefruit: Imported (7) Range	Grapefruit: Imported (7) Average
Juice per cent.	35·4 —63·0	45·4	36·9 —62·2	49·9	30·5 —55·2	43·5	32·3 —45·3	40·1
Total solids (gm. per 100 ml.)	8·2 —12·7	10·7	9·2 —11·9	10·9	7·0 —10·7	8·6	8·2 —11·3	9·6
Citric acid (gm. per 100 ml.)	0·47— 1·32	0·79	0·55— 1·25	0·97	0·92— 1·94	1·39	1·18— 2·56	1·63
Ml. N/10 soda per 10 ml.	6·7 —18·9	11·1	7·8 —17·8	12·3	13·1 —27·9	19·6	16·9 —37·4	23·5
Total solids/acid ratio	8·3 —25·1	15·1	7·4 —19·9	13·3	4·6 — 8·9	6·5	4·4 — 9·5	6·1
Total sugars (gm. per 100 ml.)	5·53— 8·84	7·28	5·64— 9·41	7·42	4·26— 7·48	5·07	3·88— 7·27	5·37
Sucrose (gm. per 100 ml.)	3·58— 5·23	4·32	2·60— 6·71	3·97	1·43— 4·28	2·14	1·23— 3·53	2·04
Reducing sugars (gm. per 100 ml.)	1·93— 4·13	2·95	1·83— 4·81	3·57	2·08— 4·00	2·92	2·51— 4·58	3·33
pH	3·7 — 4·3	4·1	3·5 — 4·4	3·9	3·3 — 4·0	3·6	3·3 — 3·5	3·4
Vitamin C (mgm. per 100 ml.)	36·6 —62·2	49·6	35·0 —66·2	52·3	33·3 —49·0	39·6	30·9 —42·2	36·7
Sugar/acid ratio	5·3 —17·3	10·3	5·4 —16·8	9·3	2·2 — 7·0	4·0	2·2 — 6·2	3·5

Figures in brackets indicate numbers of samples examined.

TABLE VI.

The Composition of Citrus Fruit of Various Countries

Orange

	Florida (1)	Palestine (2)	Australia (3)	Texas (4)	South Africa (5)	Jamaica (6)	California (7)	Rhodesia (8)	India (9)	Ceylon
Juice per cent.	—	37·0 —47·6	21.3 —45·9	35·1 —78·4	—	—	—	45·5 —53·9	—	35·4 —63·0
Citric acid (gm. per 100 ml.)	0·7 — 1·1	1·1 — 2·1	0.8 — 2·0	0·4 — 1·2	0·4 — 1·8	0·7 — 1·1	1·1 — 1·7	0·6 — 1·9	0·8 — 1·2	0·5 — 1·3
Total solids (gm. per 100 ml.)	11·8 —12·6	11·1 —14·8	9.6 —13·2	7·7 —14·5	—	10·7 —12·5	—	9·1 —11·5	—	8·2 —12·7
Total sugars (gm. per 100 ml.)	8·5 — 9·3	7·1 — 9·2	6.8 —10·9	5·2 —10·7	3·1 —11·3	—	8·4 —10·6	—	7·4 — 7·9	5·5 — 8·8
Reducing sugars (do.)	3·5 — 4·5	4·4 — 6·0	5.6 — 8·9	1·9 — 4·6	2·2 — 5·8	—	4·1 — 5·2	—	3·4 — 4·3	1·9 — 4·1
Total solids/acid ratio	11·0 —17·1	5·9 —11·1	5.7 —16·1	7·0 —39·3	—	9·6 —14·2	—	5·1 —15·9	—	8·3 —25·1
Vitamin C (mgm. per 100 ml.)	36·0 —77·0 (13)	—	—	—	44·0 —73·0 (12)	—	—	—	32·8 —67·7 (11,14)	36·6 —62·2
pH	3·2 — 3·6	2·7 — 3·5	—	3·2 — 4·3	3·6 — 4·6	—	—	—	—	3·7 — 4·3

Grapefruit

	Florida (1)	Trinidad (10)	Puerto Rico (10)	Texas (4)	South Africa (5)	Jamaica (6)	Ceylon
Juice per cent.	—	—	—	35·9 —58·9	—	—	30·5 —55·2
Citric acid (gm. per 100 ml.)	0·9 — 1·4	1·0 — 1·1	1·1	1·0 — 1·4	1·5	0·8— 1·5	0·9 — 1·9
Total solids (do.)	6·9 — 9·7	8·6 — 9·2	8·1	8·3 —10·5	—	9·8—11·8	7·0 —10·7
Total sugars (do.)	4·8 — 6·2	6·5 — 7·3	4·8	5·7 — 7·0	5·5	—	4·2 — 7·5
Reducing sugars (do.)	3·4 — 4·0	4·8 — 5·1	3·1	2·3 — 3·2	4·6	—	2·1 — 4·0
Total solids/acid ratio	7·2 — 7·8	8·3 — 9·0	7·1	7·7 — 9·0	—	7·3 —13·5	4·6 — 8·9
Vitamin C (mgm. per 100 ml.)	31·0 —60·0 (13)	—	—	—	—	—	33·3 —49·0
pH	3·0	3·1 — 3·3	—	3·2 — 3·3	3·4	—	3·3 — 4·0

Figures in brackets indicate references to literature.

DEPARTMENTAL NOTES.

ARTIFICIAL INSEMINATION OF CATTLE

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VETERINARY RESEARCH OFFICER

IN *The Tropical Agriculturist*, October, 1938, page 231, it was announced that tests on artificial insemination of cows had been carried out at the Veterinary Laboratory, Peradeniya, and that facilities were available for extended trials. This note is published to announce the birth of the first two calves to be born in Ceylon as the result of artificial insemination.

The semen used was collected by means of the Cambridge pattern artificial vagina. This consists of a cylinder into which is inserted a rubber tube (like the inner tube of a motor tyre) which is doubled over at the ends. The space between the cylinder and the rubber is then filled with water at body heat, and the inside of the tube lubricated with vaseline. A glass receptacle is fitted in the upper end to receive the sperm.

A cow in heat or a quiet cow which is not in heat is used for collecting semen. It is placed in a service trevis, preferably in a place normally used for serving cows, so that the bull when brought to the cow anticipates service.

When the apparatus is ready, the bull is led up to the cow. The collector is on the right side of the cow, holding the artificial vagina by the middle, mouth downwards. As the bull mounts, the artificial vagina is interposed against the flank of the cow with the opening directed towards the penis at an angle of 45°. As soon as the penis comes in contact with the warm lubricated surface of the artificial vagina, the bull ejaculates into the glass cup at the upper end of it. The cup is removed and the semen in it quickly covered with a layer of medicinal liquid paraffin. The semen thus obtained is examined macroscopically and microscopically for quantity, colour, consistency, and mobility of spermatozoa.

A bull normally gives 5–7 c.c. of semen at one ejaculation. A cow is inseminated while on heat, or a few hours (up to about eight) after the end of heat, and half to one c.c. of undiluted semen is injected into the uterus straightaway, or diluted with physiological saline if kept in the refrigerator for any length of time.

The actual operation consists of passing a speculum into the vaginal passage of the cow to expose the entrance to the uterus. When this is clearly visible, the nozzle of a syringe is introduced about 1½ cm. into the uterus and the plunger pressed gently and slowly. The syringe and speculum are then withdrawn.

First Case—

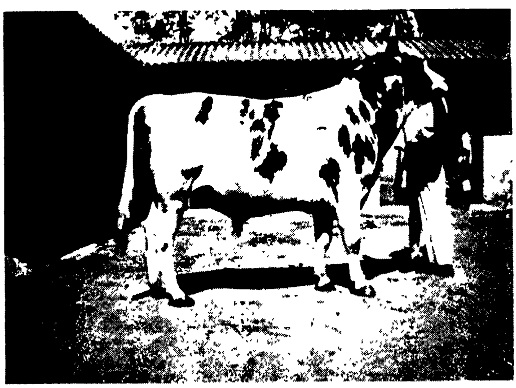
A red cross-bred cow, 11 years old with a history of having had five calves previously, belonging to a private owner living close to the Veterinary Laboratory, was inseminated on September 2, 1938. It showed signs of heat 36 hours previous to insemination. A stock of semen was available in the Laboratory collected from the imported Ayrshire bull (see photograph) on August 30, 1938. This was examined for mobility and was found quite suitable for insemination. One c.c. of diluted semen was used, the diluting fluid being physiological saline. This semen was 68 hours old when used.

A bull calf, brown with patches of white, was born on June 9, 1939. It weighed 52 lb. at birth. The length of pregnancy in the mother animal was 9 months and 7 days or 280 days (see photograph of cow and calf).

Second Case—

A red and white heifer, about 18 months old, belonging to a private owner in Kandy, was inseminated on September 7, 1939, with 1 c.c. of undiluted semen, a few minutes after collection from the imported Kerry bull " Carmoney Hero (11) ". Being a heifer certain anatomical difficulties were encountered with regard to passing of speculum. An effort was made to inject the semen as near the cervix as possible.

A dark-brown calf weighing 56 lb. was born on June 16, 1939. The length of pregnancy of the mother animal was 9 months and 6 days, or 279 days.



Blocks by the Survey Department.

THE TRANSPORT OF HATCHING EGGS FROM GREAT BRITAIN TO CEYLON BY AIR MAIL

M. CRAWFORD, M.R.C.V.S.,
DEPUTY DIRECTOR (ANIMAL HUSBANDRY) AND GOVERNMENT VETERINARY SURGEON

THE considerable expense involved when poultry is imported from Great Britain by steamer has been a hindrance to the introduction of improved strains to Ceylon. When adult birds are imported from Great Britian difficulty is frequently experienced in getting them acclimatized to the changed conditions; this is especially so when the imported birds are taken to low-country districts.

The possibility of getting good stock at a lower cost by means of hatching eggs has been considered by many poultry farmers.

In the past a number of breeders have experimented with eggs brought from Great Britain by steamer. The results have been very variable. In some cases reasonably good hatches have been obtained but many attempts have been failures. The good results have generally been obtained when the owner was travelling by the same steamer as the eggs and was able to arrange for special attention. Transport by steamer has the great disadvantage that the eggs are generally nearly one month old by the time they arrive in Ceylon. Probably this accounts for the many poor results obtained and for the fact that transport of hatching eggs by steamer has never become very popular.

The saving in time which could be effected by using the regular air services now in operation has induced some breeders to experiment with this method. The saving in time is of course offset by the considerably higher freight charges.

With a view to testing the possibilities of air transport, a batch of 24 eggs was obtained from England by the Department of Agriculture and the results are now published for the information of any poultry breeder who may contemplate importing hatching eggs by air mail. The story of this batch of eggs is perhaps best given in diary form.

April 23	..	Eggs laid on the farm of Mr. Y. Watanabé a prominent breeder of R. I. R.s in Surrey
April 25	..	Sent to London by car
April 26	..	Put on board the K. L. M. plane
May 3	..	Arrived Colombo having been transferred from the K. L. M. plane at Karachi. On arrival they were taken over by Messrs. Thomas Cook and Son who put them on the train
May 4	..	Arrived at Peradeniya by train
May 5	..	Set under village hens after having been rested for 24 hours. The eggs were 12 days old by the time they were put under the hens
May 12	..	They were tested. At the test 7 eggs were removed, 1 being infertile, 1 having a blood spot, and 5 having broken yolks
May 19	..	Retested. Result: 16 contained well-developed embryos and 1 was doubtful
May 25	..	Eggs hatched. Result: 16 good healthy chicks and one dead in shell

That is just under 67 per cent. of the total eggs set, a result which must be considered very good in the circumstances.

COSTS

		£	s.	d.
Price of 24 eggs	..	0	16	0
Cost of 2 egg boxes	..	0	3	10
Air mail charges from London to Karachi	..	1	11	1
		2	10	11 or

approximately Rs. 33.

		Rs.	c.
Air mail charges from Karachi to Colombo	..	13	13
Clearing charges, customs, &c.	..	4	22
Rail freight Colombo to Peradeniya	..	0	20
Total	..	17	55

		Rs.	c.
That is 16 day-old chicks cost	..	50	55
Cost of one chick	..	3	16

METHOD OF PACKING

The eggs were sent in two boxes made of plywood. Each box was divided into 12 compartments by thin wooden strips. Each compartment was lined with felt and a pad of felt about one inch thick was laid on top of the eggs under the lid. The lid of the box was *not* nailed down: it was secured by strong string. The results obtained show that this type of box is suitable for the purpose. Unnecessarily heavy boxes should be avoided as the air freight charge is according to weight.

PRICE OF EGGS

It is usual for breeders in England to charge higher prices for hatching eggs in the months of January, February, and March. A considerable reduction is made in April. This is a good month to buy if cheapness is a consideration because fertility is usually very good in April and eggs from the best pens can be obtained at much lower rates than earlier in the year.

The Editor would be glad to have the results obtained by any other breeder who may have had eggs sent from Great Britain or Australia by Air Mail.

CULTIVATION OF KNOL KHOL IN THE HANGURANKETA DISTRICT.

H. A. PIERIS, B.A. (Cantab.), A.I.C.T.A. (Trinidad).

KNOL khol or khol-rabi, *Brassica cauioropa* (*Cruciferae*) is grown essentially for its tuber which develops above ground into a globular stem upon which the scars of fallen leaves are left behind.

In the Hanguranketa area of Nuwera Eliya district, it is gaining popularity as a local vegetable. It is in prime condition for the table when the stem is about the size of a small orange. If allowed to grow too large, the root becomes fibrous and unpalatable. When harvested in the semi-developed stage it makes an excellent boiled or curried vegetable.

In the Hanguranketa district, knol khol is cultivated as a pure market-garden crop by small-holders and by a few others owning boutiques, who sell the crop locally. However, the greater portion of the crop finds its way to the Kandy market where it is sold for prices ranging from 2 to 7 cents per tuber and sometimes more.

In view of its keeping qualities after harvesting, this vegetable is gaining popularity as the cultivator is not compelled to dispose of his crop to the first buyer as he is often obliged to do in the case of more perishable vegetables.

The tubers are lifted according to the demand. They can be harvested from the third to the fourth month after planting. In plots that are well maintained, the harvest should be completed by the third month as by this time the tubers are in prime condition for cooking.

Knol khol is a crop admirably suited to a dry and cold climate as is experienced in the highland areas of the Hanguranketa district. It is best suited to a heavy, loamy soil with a good supply of organic matter. It will not grow in a sandy soil deficient in humus, nor will it thrive under waterlogged conditions.

In the Hanguranketa district, the lands are undulating and well drained. The days are warm but the nights and early mornings are cold. In such conditions knol khol thrives admirably.

Sowing is done at different periods between late September and April. Early sowing is undertaken in order to catch the

market during Christmas and the New Year. As a rule, the main seasons begins with the April rains, so that the crop can be gathered in time for the Perahera season in Kandy and Hanguranketa. It is advisable to sow the seed in the nursery at intervals of about a fortnight to ensure a continuous supply of tubers.

Nurseries should be carefully prepared, and land on a level site selected for the purpose. The top soil should be turned over twice with mammoties and then pulverized with a digging fork to provide a fine tilth. Dry cattle manure, in powder form if possible, should then be applied. The proper preparation of the nursery is most important as a good tilth ensures the vigorous growth of seedlings. Nursery beds should not be more than two feet broad, but the length may vary according to the supply of plants required. Beds should be at least six inches above ground-level and the soil allowed to settle before the seed is sown. Seed at the rate of 8 oz. per acre is sown broadcast mixed with a small quantity of fine sand or wood-ashes to ensure an even distribution.

The soil should be well watered before and after sowing Nurseries should be shaded from the noon-day sun until the seeds germinate and while the young plants are tender, but the shade should be gradually removed when the plants are older and stronger and are ready for transplanting. Seedlings are ready to be transplanted when 2–3 inches high about 21 days after sowing in nurseries. Care should be taken not to damage the rootlets when uprooting. This can be avoided by watering the beds thoroughly before the plants are up-rooted. Before transplanting, the land should be opened with a plough or mammoty. It should be cross-ploughed and harrowed or well pulverized with digging forks. If the soil is deficient in organic matter, an application of five to ten tons per acre of cattle manure or compost, depending on the fertility of the soil, should be given about a week or a fortnight before the beds are prepared. Beds should be opened 3 to 4 feet in width and of a convenient length according to the lie of the land. Plants should be removed from the nursery preferably on a dull and showery day. Transplanting is done in rows 15 inches apart, the plants being placed 12 inches apart in the rows. After transplanting, shade should be provided by fixing temporary trelisses until the plants have established themselves in their new environment.

The first cultural operation, two weeks after transplanting, is to loosen the earth round the plants and to fork in around each plant a handful of powdered cattle manure or powdered dry-fish refuse. Watering should be done regularly depending

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upon the prevailing weather conditions. As the stems begin to thicken, the soil around the plants should be loosened lightly, but the stems should on no account be damaged or earthed up.

Harvesting is done by hand, the tubers being first loosened with a digging fork.

In the Hanguranketa district two varieties of Indian knol khol, purple and green, are cultivated, the latter being the more popular of the two.

This crop should do well in most mid-country districts especially in the suburbs of the larger towns.

CHILLIES.

ARTICLES describing the experiments carried out by officers of the Department of Agriculture on the cultural and manurial operations in chilli cultivation have been published in recent numbers of *The Tropical Agriculturist.* As it may be of interest to the readers of this journal to know the actual results obtained in cultivating chillies at one of the major experiment stations of the Department, we present below the Cultivation Sheet in respect of an area of three acres under this crop at the Experiment Station, Anuradhapura.

The preparation of the land, the various cultural measures adopted between the planting and harvesting of the crop, the yields obtained, and the income derived are described in the Cultivation Sheet in concise form. In addition to the artificial fertilizers mentioned in the Cultivation Sheet, some farm-waste and cattle dung collected at the Station in a pit was applied.

While an area of three acres is hardly sufficient to demonstrate the commercial possibilities of the cultivation of this crop, the figures published will, no doubt, serve to give some indication of the yields and income which might be expected.

With regard to the value of the crop shown in the Sheet, a brief explanation is necessary. The total value of the harvest is stated as Rs. 166·19 per acre or Rs. 498·59 for the whole area of three acres. Of this amount the actual sum of money realized was Rs. 188·06, being the value of 15 cwt. 78 lb. 8 oz. of green chillies which were sold as shown below :—

		Rs.	c.
9¾ cwt. at Rs. 12 a cwt. (wholesale)	..	117	0
4 cwt. at Rs. 12·50 a cwt. (wholesale)	..	50	0
1½ cwt. at Rs. 10 a cwt. (wholesale) ..	..	15	0
— 50½ lb. at Re. 0·12 a lb. (retail)	..	6	6
15 cwt. 78 lb. 8 oz.		188	6

The greater portion of the crop was converted into dried chillies, but the Manager, Experiment Station, Anuradhapura, was unable to sell the dried produce as he required seed for distribution in the district. He had an offer of Rs. 18 a cwt. for the stock of 15 cwt. 99 lb. 4 oz. of 1st grade dried chillies from a local market keeper, but he declined the offer for the reason

mentioned above. Had he disposed of the dried chillies at this price, he would have realized Rs. 285·95.

Similarly, he had an offer of Rs. 8 a cwt. for a quantity of 3 cwt. 8 lb. 2 oz. of 2nd grade dried chillies. This offer, too, was not accepted as he had decided to retail this quantity to the labourers at the station at 10 cents a pound. The income that would have been realized had he sold the 2nd grade produce at Rs. 8 a cwt. would have been Rs. 24·58. For practical purposes, therefore, the total income derived was Rs. 498·59 for the whole plot of three acres.

The cost of cultivation was Rs. 319·85 for the total area. The profit derived from the cultivation, therefore, works out at Rs. 178·74 for the plot, or Rs. 59·58 per acre. It is believed that this profit is a substantial one for a crop of this nature.

CULTIVATION SHEET.

Maha : 1938—1939.

ANURADHAPURA AGRICULTURAL STATION.

Crop : Tuticorin Chilli.

Experiments : Rotation crop unirrigated for trial as to its possibilities in the District and to obtain seed for distribution.

No. of Field or Plot : 30. *Area in Acres : 3.*

Cost of Cultivation.	Per Plot. Rs. c.	Per Acre. Rs. c.
Share of Permanent Improvement	—	—
Preparatory Cultivation	23 25	7 75
Manure and Manuring (Manure used 6 cwt. nitrate of soda at Rs. 6·55 a cwt.)	59 50	19 83⅓
Seeds and sowing (1½ lb. seeds at Rs. 2 a lb.)	24 90	8 30
Transplanting	22 50	7 50
After cultivation	66 40	22 13⅓
Watering	9 0	3 0
Harvesting, Threshing, Cleaning, &c.	108 82½	36 27½
Spraying and dusting	5 47½	1 82½
Total	319 85	106 61⅔

Produce.	Yield. Per Plot. Cwt. lb. oz.	Yield. Per Acre. Cwt. lb. oz.	Value. Per Plot. Rs. c.	Value. Per Acre. Rs. c.
1. Green chillies	15 78 8	5 26 2⅔	188 6	62 68⅔
2. Dried chillies 1st grade	15 99 4	5 33 1⅓	285 95	95 31⅔
3. Dried chillies 2nd grade	3 8 2	1 2 11⅓	24 58	8 19⅓

Total value per acre	166 19⅔
Less expenses per acre	106 61⅔
Balance, profit	59 58

Rates.

1. $9\frac{3}{4}$ cwt. green chillies at Rs. 12 per cwt.
2. 4 cwt. green chillies at Rs. 12·50 per cwt.
3. $1\frac{1}{2}$ cwt. green chillies at Rs. 10 per cwt.
4. $50\frac{1}{2}$ lb. at 12 cents (green chillies).
5. At Rs. 18 per cwt. 1st grade } Dried chillies.
6. At Rs. 8 per cwt. 2nd grade } Dried chillies.
7. Seed at Rs. 2 per lb.

Date.	Description of Work.	Bullock pairs at Re. 1.	Men at 60c.	Women at 30c.	Boys at 45c.	Cost of Work. Rs. c.
August	..Preparing beds for nurseries 3 × 30′ 12 beds manuring, &c	—	7	—	—	4 20
Do.	..Sowing and covering seed	—	2	—	—	1 20
Do.	..Upkeep of nursuries	—	7	—	4	6 0
September	Do. ..	—	10	—	10	10 50
Do.	..Ploughing main field	4	8	—	—	8 80
Do.	..Harrowing ..	2	4	—	—	4 40
Do.	..Transporting and spreading manure compost	4	4	12	—	10 0
October	..Lining out and blocking out Experiment areas and lines for transplanting	—	13	—	3	9 15
Do.	..Levelling Experiment plots..	—	5	13	7	10 5
Do.	..Transplanting, uprooting, and transporting seedlings	—	—	14	6	6 90
November	Do. ..	—	—	14	5	6 45
Do.	..Filling vacancies	—	—	5	2	2 40
Do.	..Watering ..	—	—	10	—	3 0
Do.	..Inter cultivating	3	6	—	—	6 60
Do.	..Weeding and earthing	—	—	$58\frac{1}{2}$	6	20·25
Do.	..Spraying and dusting	—	2	—	—	1 20
Do.	..Manuring manurial plots artificials..	—	2	—	—	1 20
December	..Watering ..	—	—	6	—	1 80
Do.	..Cultivating	4	8	—	—	8 80
Do.	..Weeding ..	—	—	29	2	9 60
Do.	..Manuring and forking manure artificials	—	15	—	—	9 0
January	..Picking ..	—	—	$57\frac{1}{2}$	8	20 85
Do.	..Weeding and earthing	—	—	$40\frac{1}{2}$	—	12 15
Do.	..Spraying and dusting	—	2	—	$1\frac{1}{2}$	1 $87\frac{1}{2}$
February	..Picking ..	—	—	63	15[1]	25 $87\frac{1}{2}$
Do.	..Weeding and earthing up	—	—	16	—	4 80
Do.	..Watering ..	—	—	11	2	4 20
Do.	..Spraying ..	—	4	—	—	2 40
March	..Picking ..	—	—	$100\frac{1}{2}$	17	37 80
Do.	..Weeding ..	—	—	6	—	1 80
April	..Picking ..	—	—	21	4	8 10
Do.	..Drying and sorting	—	—	48	4	16 20
	Total ..	17	99	525	97	277 55

Progress of crop and observations of interest.

Date of sowing nurseries :—19th September. Seed rate ½ lb. per acre.

Date of 50 per cent. Germination :—1st October. *Distance of Planting* 3′ × 3′.

Dates of transplanting :—29/10/38 & 30/10/38 two seedings per hill
3/11/38 & 4/11/38

Dates of 50 per cent. flowering :—10/12/38 & 15/12/38. No. of beds Reg. per acre 4 beds of 3′ × 30′. 2 oz. per bed.

Artificial manure :—applied Nitrate of Soda at 2 cwt. per acre in two applications one 3 weeks from transplanting ; one two weeks from the 1st application ; *compost* 20 cart loads approximately 15 tons per acre.

Diseases (1) Chlorosis, (2) leaf curl, (3) *Sclerotium Rolfsii.*

None of the diseases were troublesome.

With the three acres three experiments were carried out.

(1) ½ acre (9 plots approximately 1/20th of an acre in extent) a comparative trial with Hyganic manure, cattle manure and nitrate of soda in two applications.

(2) A uniformity trial 112 plots each consisting of 13 × 8 plants with a border all round.

(3) A spraying trial for control of chilli leaf curl 5 treatments replicated four times each plot 24′ × 45′. The treatments were (*a*) spraying with nicotine sulphate ; Kerala soap ; Ceylon Insecticidal soap ; dusting with lime and Sulphur and a control.

Details of each experiment were recorded in log books maintained.

Produce Harvested.

1 Date.	2 Kind of Produce and quantity harvested in unprepared form. Cwt.	lb.	oz.		3 Date.	4 Quantity taken over to produce Register. Cwt.	lb.	oz.	
January ..	15	4	0	Green chillies	January ..	15	4	0	Green chillies
February ..		74	8	,,	February ..		74	8	,,
Total ..	15	78	8			15	78	8	

Date	Cwt.	lb.	oz.		Date	Dried chillies. 1st. Cwt.	lb.	oz.	2nd. Cwt.	lb.	oz.
January ..		17	7½	Ripe chillies	February ..		3	14	—		
February ..	17	16	3	,,	February and March	3	73	5	1	4	0
March ..	36	75	4	,,	March and April	10	100	8	1	41	12
April ..	3	108	12	,,	April ..	4	33	9		74	6
	57	105	10½			15	99	4	3	8	2

DAIRY SCIENCE ABSTRACTS

(The following note issued by the Imperial Bureau of Dairy Science, Shinfield, near Reading, England, and received through the Agricultural Adviser to the Secretary of State for the Colonies, is published for the information of the readers of *The Tropical Agriculturist*.—Ed.)

THE IMPERIAL BUREAU OF DAIRY SCIENCE will shortly publish a quarterly journal called Dairy Science Abstracts, the purpose of which will be to provide a survey in English of the current literature of dairy science from all parts of the world. The Table of Contents printed below indicates the subjects for which this journal will contain references, abstracts, and reviews of current scientific publications. At present this literature is published in a variety of languages and scattered in a large number of journals, many of which are not generally available to workers in dairy science. Particular attention, therefore, will be paid to information published in less familiar languages or in journals with a limited distribution.

The first number will appear in May, 1939, and will deal with literature received or examined by the Bureau during January, February, and March, 1939. Thereafter a number will appear every three months; four numbers will constitute a volume. To facilitate reference each number will contain an author index, and each volume, author and subject indexes.

The annual subscription will be—

	s.	d.
For residents of the countries of the British Commonwealth and the Anglo-Egyption Sudan who send their subscriptions direct to the Bureau ..	20	0
For all other subscribers	25	0
Single parts, each	7	6

All these prices include postage. Particulars of trade terms will be supplied on request.

TABLE OF CONTENTS

Husbandry—

Breeds and breeding for milk; feeding and milk; recording; technique of milk production.

Technology—

Milk (liquid trade) ; cream ; butter ; cheese ; dried and concentrated products ; ice cream ; other dairy products ; disposal of wastes ; dairy engineering ; buildings ; dairy equipment ; transport of milk and milk products.

Control and Standards.

Economics—

Dairy surveys, (*a*) production, (*b*) distribution ; processing and manufacture ; utilization of products and by-products.

Physiology—

Physiology of dairy animal in relation to milk secretion ; milk and milk products as food.

Bacteriology and Mycology—

General ; milk production ; processing, manufacture and products ; analysis ; defects ; animal diseases as affecting milk and milk products ; milk and public health.

Chemistry and Physics—

General ; milk and dairy products ; processing and manufacture ; analysis ; defects.

GHEE DEPOT AT MANAMPITIYA.

It is hereby notified for general information that the ghee depot at Manampitiya which was under the management of the Department of Agriculture has been sold to Mr. S. Masilamany, Police Vidane, Huruwila, Manampitiya, on June 15, 1939, and is no longer owned by Government.

E. RODRIGO,
Acting Director of Agriculture.

Peradeniya, July 8, 1939.

SEASONAL PLANTING NOTES

CALENDAR OF WORK FOR JULY

T. H. PARSONS, F.R.H.S.,

CURATOR, ROYAL BOTANIC GARDENS, PERADENIYA

IN south-west monsoon areas this is a good time for planting, and any such operations remaining should be completed this month.

Propagation and re-potting of pot plants are the other main operations called for.

The handsome garden gerbera or Barberton Daisy is a subject on which much advice is sought as to when and how often these should be replanted. The original habitat of the plant was South Africa. There the plant experiences a much lighter rainfall than in most parts of Ceylon, but for all that the plant adapts itself to our varying conditions to a very extraordinary extent.

The gerbera does not like disturbance of root by re-planting too often and some of our best plants at Peradeniya have not been so treated for the past 5 years. When new plants are required these are obtained from root sections of the oldest clumps, leaving, say, half of the parent plant intact and undisturbed in the bed. These sections can be divided up into single plants and given an open position in a well-drained soil and away from the roots of trees. The young plants take a considerable time to establish themselves and spread, and often 6 months or more elapse before the flowering of the new plant. A dressing of well-decomposed manure forked around the plants every six months is very beneficial.

Many bulbs are now in flower, and a very attractive variety not sufficiently cultivated is the *Zephyranthus* or Ceylon Crocus. Planted in grass under the shade of tall trees, it gives a typical woodland effect. It should be planted in small pockets made in the grass, at a depth of about 3 inches. It is of course, best suited to areas not under the mower to any extent.

A fernery is an attraction anywhere in the tropics, the most satisfactory areas being those with up-country conditions. In low elevations, however, much can be done and now is the

time to undertake the building or renovation of these. An undulating bed or border is preferable to a flat one, and the taller types of fern should be used as a centrepiece on which to build around. The low-country tree fern (*Alsophilia glabra*) and the giant *Angiopteris* are suitable subjects for a centrepiece around which can be planted such attractive specimens as Maidenhairs (*Adiantum*), gold and silver ferns, *Nephrolepis* and others, together with the many varieties of begonia now available. Sources of supply of fern varieties must necessarily be from the local jungle and application to the Conservator of Forests for permission to remove small quantities would doubtless be readily conceded.

At this time of the year, which is the Australian winter, Colombo agencies import planting material such as fruit trees, roses and gladioli bulbs. Since all arrive in dormant condition, and the planting season still continues in the south-west portions of the Island, no time should be lost in getting these in. The fruit trees for low-country and mid-country are, in general, grapefruit, oranges, mandarin, and lemon; they should be planted in holes 3 feet deep and 3 feet wide and refilled with the addition of one fifth of a cart-load of well-rotted manure per hole.

Spacing should be 25 by 25 feet for grapefruit, 20 by 20 feet for oranges and lemons, and 18 by 18 feet for mandarins. Many casualties occur by planting too deep, and shallow planting is always preferable for citrus. The surface roots should in fact be not more than one inch from the soil surface.

Roses are best suited to up-country gardens but enthusiasts make much of them in the low-country also. Last month's notes give details of this subject, but it should here be emphasized that imports received from Australia or other countries should not lie about unplanted even if they are in a dormant state. The sooner they are planted the better, the only restriction being to avoid planting in very wet weather.

Gladioli are very attractive bulbs for up-and-mid-country and with care can be made much of in low-country also. The bulbs are best planted in clumps of half a dozen or so, the bulbs being planted one foot apart from each other. They appreciate humus, though not cattle manure particularly; leaf mould used with decomposed sweepings and grass cuttings well mixed up make a suitable form of humus for all bulbs.

Budding and grafting can best be done towards the end of this month, throughout August and the early days of September.

The mango crop is in most areas proving a heavy one though less so in the proper mango district of Jaffna. Mangosteen and

durian have set fruit in remarkable quantities, and the crop this year indicates very heavy yields though fruits may be smaller than usual in consequence.

Vegetable and flower seeds can be sown to maintain succession in crops, the more tender in boxes, and those of a hardier nature direct in beds. Up-country sowings of the more bi-ennial type of plant such as delphiniums and carnations, are best sown in boxes or under covered beds if required to flower during the normal up-country season of December-May. The majority of annuals are, however, best raised in September for this purpose, and orders for new seed stocks should be placed without delay.

Dahlias, now generally in full flower in up-country districts, should be watched and well staked against the strong wind. This month normally sees the end of the more unfavourable portion of the south-west monsoon, and activities of the month of August can now be looked forward to, and arranged for.

SELECTED ARTICLES

A NEW METHOD IN MANGO PROPAGATION*

EVERGREEN fruit trees, like the mango, citrus, chico, and avocado, are generally propagated by inarching and marcotting in warm countries, as it is believed that both budding and veneer grafting are not successful in the tropics. The reason is mainly based upon the fact that in cold countries one can easily utilize dormant buds which can be revived by placing them upon a functioning root stock, while in warm territories it is difficult for the budwood to harden and also the scion or buds used easily dry up with excessive heat before they become firmly established in the process of union with the tissue of the root stock. Both inarching and marcotting, besides being tedious, cannot be expected to produce a large number of vigorous young plants at one time. The resulting offspring, besides being too large to be moved thus exposing them to the danger of withering, are always weak and look old. Various methods of twig grafting have been claimed to be more satisfactory. One method is to use the whip grafted scion with a free bottom end nourished by water in tube, or inserted into moist soil. This method undoubtedly keeps the bud alive during a period long enough to perfect the union, but it requires too much labor. " Etiolation layering " is sometimes recommended to secure a large number of vigorous young plants in the tropics, but it is not always successful when the soil and temperature are not ideal. Under this circumstance, a new device for side-grafting in which immature wood is used is proposed by Ichizo Nakamura of Takao, Formosa. This device works very satisfactorily under tropical conditions in multiplying mango plants in a very speedy way. This new finding is described in the following paragraphs.

THEORETICAL STARTING POINT

In temperate countries where both budding and grafting are practised the scion species used are mostly deciduous and the buds are dormant when cut, as those on immature wood are hard to revive. In tropical countries, in the case of the mango, the development of the bud does not require a long period of dormancy, and soft wood buds can be used for grafting purposes. Moreover, the healing of the wound is much easier when the plant is active in midsummer up to early fall when the temperature is high and the regenerative power is strong. In early spring the temperature is not high

* By Tyozaburo Tanaka of Taihoku Imperial University in *The Philippine Journal of Agriculture*, Vol. 10, 1st quarter, 1939, No. 1.

and the plant is more dormant than in summer and this gives a different effect to the plant. The root stock to be worked is also larger and more vigorous with the advance of the season and it is easy to force the bud to start strong growth. This supports the theory that spring is not the proper season when to practise grafting in the tropics, since the physiological and morphological conditions of the stock plant are, in summer rather than in spring, far more conducive to make the wound heal faster, force the inserted bud to grow easier, and complete the elongation of the shoot faster. It does not require an entire season to expect a full wood growth, as the growing season is long and the temperature favors a rapid elongation. Another important difference is the evaporation power. Ordinary scions used in the temperate countries in spring are dormant and keep a considerable length of time without losing their power of regeneration as the physiological activity is slow. Scions used in the tropics, on the other hand, are always active and ready to function even during winter, and are ever subject to lose water by transpiration and respiration. Under this condition, the scion must be properly protected against loss of water, and the budwood must be waterproof as far as possible. To answer this requirement, budwoods must have neither foliage nor petiole, and the leaf scar should be water-tight with complete cork formation after the natural abscission of the petiole. This can be attained by removing the leaf blade at the middle of the petiole, before the scion is cut, and by waiting a week or so, the remaining petiole falls down with the formation of an abscission cork layer. Such wood is ready to be used as a scion. Without doing this, and if the leaves are removed at the time when the scion is cut, the cut surface of the petiole is likely to form a danger point, from which water may evaporate very quickly. Such scion will wither very rapidly and will not survive at all when used. Defoliation and healing of the leaf scar will unquestionably prevent the loss of water by the bud. Not only that. They accelerate the subsequent development of the bud into a sprout. The pre-curing of bud by defoliation renders the scion ready to start bud growth when used. This point is well explained in Mr. Nakamura's method and the factors which cause the failure of grafting in the tropics are wisely avoided and more logical processes substituted.

METHOD OF GRAFTING

In Mr. Nakamura's method, terminal or lateral buds, in an intermittent rest period between two cyclic growths, are to be used. If the terminal bud is wanted, several leaves from the top are removed, and the scion with two or three leaf scars is to be cut after the abscission of the petiole. The lower portion of the same stick can be used again, after two weeks or so, in the meantime waiting for the terminal cut to heal completely. After removing the leaf blade and the remaining petiole, the top part with several leaf scars, can be used as before for the scion. This time, the axillary buds in the uppermost position are to be developed. In a similar way, the still lower part of the same stick is available. It is better to remove all leaves of the entire shoot at the beginning, if several scions are to be obtained from the same shoot.

The scion is inserted into the notch made on one side of the immature but fully developed root stock, while the bark is still green. Two- or three-year-old stocks with brown barks are also available but they are not so good as the green ones. Still larger stocks over two centimeters in diameter should be cut back when worked on with young sprouts. When the stock is old and top working is desired, the entire trunk is cut down in early spring at a point 15 to 18 cm. from the ground. From several adventitious sprouts arising near the cut surface, one or two opposite strong shoots may be saved, and such vigorous shoots are used when they grow big enough to work on. It does not matter how big the stock is, but the part to work on must not be fully mature and dormant. When working on young plants, the stock is cut at a point 5 to 10 cm. from the ground, leaving two or three leaves, which are left untouched when the scion is inserted.

THE ROOT STOCK

The most economic and speedy way is to use one-year-old root stock, and operate in mid-summer of the same year. The mango fruits chosen to supply seed for stock, must be large enough in size, if the plant is a seedling type, and it must represent a good early strain. It is not necessary to use the seeds of big varieties, like the Carabao or Golek, because all seedling types supply good stock plant for these standard mangoes. If the Carabao mango seedling is used as the root stock of the White Golek, the scion will always outgrow the stock, but the stock of the seedling type of the mango will grow just as big as the scion or will slightly outgrow it, whenever the Carabao or White Golek is worked on to it. The seeds are planted in pots or in the ground 60 cm. apart, after removing the shell. The planting soil must be well prepared and rich in organic matter. After sowing the seeds, it is desirable to have a thin sand dressing on the surface. Upon germination of the seeds, they must be tested to show only a single plant from each seed, and smaller poly-embryonic secondary sprouts must be scraped off while they are young. The seedlings should be well fertilized to allow them to attain their maximum height and girth. In starting the work, the bigger seedlings are to be worked on first, the smaller ones next. The cutting back of the top of the stock must not be carried down too far away from the parts having closer leaf stand. In top-working old seedlings, the best results may be obtained when the plant is rather large, having at least a diameter of 12 to 15 cm. That transplanting may be made easier the seed should be planted in a longitudinally halved pot.

OPERATION AND TYING

The bottom of the scion must be cut very sharply to make an acute wedge but one side must be cut along the cambial layer as far as possible, so that both sides are not symmetrical. The cut surface must be very smooth, allowing a single draw of the knife to make an even plane. The stock is then notched by cutting it down diagonally, and the knife must be drawn straight down to make the oblique cut very sharp and even. The side to be incised must be as straight as possible. Curves should be avoided. It is preferable to work on the eastern side, as the afternoon sun may injure the graft when

it is done on the western side. The wood tissue should not be cut too deep into and the incision must not be too far away from the cambial layer. The scion wedge to be well placed must be inserted in air-tight contact with the incision surface. The tongue-like portion of the bark must not be broader than the stock notch, even if the scion is thicker than the stock. In other words, the cambial plain of the former must be completely concealed within the incision of the stock. All precaution must be taken to make the scion wound perfectly covered by the cut surface of the stock. The air-tightness of the contact surface would decide whether the union is successful or not. A long exposure of the cut surface of the scion must be strictly avoided. Therefore, the scion ready to be used must be kept, during the operation, in a tall box to prevent its cut surface drying up. The best kind of knife to use in mango grafting is one having a blade of stainless steel and sharpened on one side only. By using such a knife, oxidation of the cut surface can be prevented. The sharp edge of the knife must be straight so as not to cause any curvature on the cut surface. The best type of tying material is ordinary cotton string tape commonly used in the shop, which is composed of several thread lines pasted flat in one narrow strip. The tape must be wound close and tight so as to exclude air. Such tape will be removed one or two months after the taking of the scion when it will have increased in volume. Waxed cloth tape generally used in budding is not satisfactory, as it prevents the quick swelling of the scion in action.

TREATMENT AFTER THE OPERATION

No cover is necessary to protect the graft even in strong sunshine. After two weeks, the uppermost bud of the scion begins to swell. If it looks difficult to judge whether the graft was successful or not, observe at night with the use of a flashlight. The surviving scion looks lustrous and turgid. After the third week, the bud starts its initial growth. The internal activity of the living graft can be easily detected with the frequent visit of ants, seeking the sugary secretion of the new growth. At this time, the top of the root stock may also show new growth. These stock shoots must be shaved off with care as soon as they start to elongate. When the new growth of the scion develops and reaches a length of 30 cm. or so, the remaining top portion of the stock must be sawed off carefully at a point 5 to 8 mm. above the union.

If the scion did not take, the same stock can be worked again at the opposite side a little below the original incision.

Since no cover is used in the present method, precaution must be taken not to leave any wound of the scion in contact with the air. The success of the graft is therefore dependent upon the skill of the operator. Covering the grafted portion with soil helps injurious fungi or bacteria to the wound.

DISCUSSION

Mr. Nakamura's side working method of the mango is a good example of " soft wood grafting " which is generally believed unsuccessful in the tropics as well as in the colder countries. He found that the failure lies principally

in the adequate condition of the scion, and the lack of proper attention to safeguard its activity. The immature bud does not develop in most of the temperate species, except in a few, like the apple, plum, and the cherry. With most of the tropical species, however, it is easier to make such immature bud start growth, provided the forcing is done effectively. This can be attained by pre-curing the bud through defoliation and putting it into a vigorously growing stock during the active growing season, not in the spring-time when the bud is semi-dormant. The strong seedling cut in summer or early fall can easily stimulate the inserted bud to growth, after a certain period of curing caused by the natural drop of the petiole which, in turn, is forced by the removal of the blade. At the same time the scion is almost water-proof as the petiole scar is already well coated with cork tissue thus preventing evaporation. All these factors favor the rapid healing of the union and the easy development of the new bud. At the end of the fall, an already well developed nursery plant can be secured, and a large number of similar plants will then be available as a good supply of the budwood can be had at intervals of approximately two weeks, as stated in the preceding paragraphs. The entire grafting work is complete at the end of the year the seeding of the stock plant is started and the resulting young plants are ready to be transplanted in the next spring. In this way standard varieties, like the Carabao and the White Golek, can be obtained in a large number within a very short time. This gives an opportunity to mango planters to raise more plants of the desirable variety with less expense and labor. This fact also suggests the possibility of the mango trees being planted on a large scale as a plantation crop, since the demand for fresh fruits has increased after the invention of preparing the frozen mango meat for use in ice-cream manufacture. The canning of the mango meat is also a great possibility in tropical countries. Fruits of such varieties like the Carabao and the White Golek can be picked green before the mango fruit fly, *Chaetodacus dorsals* Hendel has a chance to attack them. They can then be satisfactorily transported and marketed before they get over-ripe. It is hoped that the present paper may be of help in the future development of the mango industry in the Far East.

NUTRITION AND REPRODUCTION*

THE maintenance of regular and healthy reproduction coupled with a sound breeding policy is clearly essential to the development of successful animal husbandry. Until recent years the major causes of reproductive troubles were commonly sought in the field of disease, but conclusive evidence is now available that in very many cases the basic causative factor primarily arises from faulty nutrition. The effects of such factors, moreover, are not necessarily exercised directly upon the sex organs, but may affect their activities only indirectly through the establishment of abnormalities in other parts of the body whose healthy co-operation is essential to the optimum working of the reproductive processes.

That general bodily condition may react upon reproductive efficiency has long been known to observant breeders. Extremes of leanness and fatness must be avoided. The half-starved animal, whether male or female, is likely to be slow in arriving at puberty and of low breeding efficiency thereafter. The female in such condition may for a time produce healthy offspring but only through incurring a strain upon her body that may soon cause the production of dead or weakly offspring and permanent damage to herself. The underfed male will show his weakness in reduced number and vigour of the sperms. At the other extreme, the detrimental effects of over-fatness are revealed in the widespread experience that in both sexes the maintenance of animals in "show" condition for more than short periods is generally accompanied by low fertility.

Under-nutrition may arise from a general deficiency of energy supply or from deficiency of one or more of the specific essential factors, such as vitamins or minerals, or from the combined effects of more than one deficiency, and the nature of the reaction upon reproductive activity will vary with the character of the nutritional defect. In the female an effect that seems to be common to all types of nutritive deficiencies is a disturbance of the œstrous cycle, leading to irregularity or in severe cases to actual cessation.

ENERGY REQUIREMENTS

The minimum energy requirement for reproduction in the female is obviously that represented by the energy stored in the form of new tissues in the growing fœtus and its membranes, in the enlargement of the uterus and the development of the mammary glands. To estimate the actual energy requirement, however, this minimum must be increased, since even under the most favourable conditions it is hardly possible for the whole of the available energy that is applied to the reproductive process to be stored up in the new tissues. In other words,

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* By Charles Crowther, M.A., Ph.D., of Harper Adams Agricultural College, reprinted from *The Journal of the Ministry of Agriculture*, Vol. XLV, No. 8, 1938.

we must provide not merely for the material produced but also for the work of reproduction. Each of these items, which together form the total energy requirement, will vary at different stages of the gestation period.

That the rate of storage of energy in the fœtus and other uterine products rises steadily as gestation progresses has been well demonstrated in studies with young sows at the Illinois Agricultural Experiment Station. In these studies it was found that with a sow producing a litter of eight pigs the daily storage of energy rose from less than 2 Calories in the first week to 272 Calories in the sixteenth week of gestation. Similar increases were also recorded in the storage of protein and mineral elements. For the whole period the average daily storage of energy was 104 Calories, and assuming that the additional storage of energy in the growth of the mammary glands would not exceed 10 per cent. of this figure, an estimate of an average daily requirement of 115 Calories of net energy to cover the specific needs of reproduction was arrived at. When this is compared with the net-energy requirement for maintenance of gilts of the weight used in these studies (200 lb.), which was put at 2,000 Calories, it will be seen that the extra energy requirement of the in-pig gilt as compared with the "empty" gilt amounts to no more than 5 or 6 per cent., and even at its highest point in the closing week of gestation when it may have risen to 300 Calories, this represents but a 15 per cent. addition to the basic maintenance requirement. If these energy figures be converted into terms of the corresponding weights of digestible nutrients, the ratios will remain much the same and we may conclude that as far as extra energy supply is concerned the additional requirements for pregnancy of the sow are trivial in the early stages of gestation and at no stage are likely to exceed 20 per cent. of the basic maintenance requirement. With longer period of gestation of the cow, the extra energy requirement in proportion to the size of the animal is probably even smaller.

These computations leave out of account, however, the bodily condition of the mother herself, and if this is low at the onset of pregnancy it will clearly be advisable to feed on a more liberal scale until the desirable state of bodily fitness has been attained. This is all the more important since some draft upon the reserves of the body is almost certain to be made, even with abundant food supply, to sustain the milk flow subsequent to parturition, when it reaches its maximum level.

A further point to keep in mind in connexion with these estimates of food (energy) requirements is that they assume that the ration is adequate with regard to all other essential factors. Should there be a deficiency of protein or phosphorus, for example, then probably a greater amount of food will be required to secure the same level of storage of energy. The nature of the ration requires separate consideration therefore, apart from the question of energy supply.

PROTEIN REQUIREMENT

Bearing in mind that the dry substance of the fœtus and other products of gestation is rich in protein, it follows that the trend of protein storage with advance of gestation will be similar to that of energy, small in the early stages and rising to a relatively high level at the end. Thus, in the Illinois studies

referred to above the daily rate of storage of crude protein rose from 0·5 grm. in the first week to 33 grm. in the sixteenth week. This is a far smaller relative increase than that found in respect of energy storage, which is to be expected since, as the fœtus develops, an increasing proportion of the retained energy is stored in the form of fat.

Over the whole period the average rate of protein storage was 14 grm. per day,* which may be raised to 16 grm. to allow for protein stored in the increase of mammary gland. As to how much digestible protein should be included in the food supply to provide for this storage, this will depend upon the " biological value " (or " quality ") of the food protein. If this be assessed for common types of rations at 50 per cent., the average daily requirement of digestible protein in the food to secure an average storage of 16 grm. would be 32 grm. Similarly, to provide for the 35 grm. daily storage in the last week of gestation about 70 grm. of disgestible food protein will be needed. According to American estimates the pig of 200 lb. live weight requires for maintenance about 100 grm. of protein per day. German estimates give the much lower figure of 60 grm. but even taking the higher figure it will be seen that the additional requirement for food protein imposed by pregnancy is no less than 32 per cent. on the average of the whole period and 70 per cent. in the closing stage of gestation. Although, therefore, the total food requirement during pregnancy as indicated above may be but little increased, the protein requirement is substantially increased and therefore the composition of the ration must be adjusted, by reducing the cereal fraction and increasing the protein-concentrate fraction, to ensure the necessary increase of protein supply. The same principles apply to other classes of livestock, but where the rate of development is slower the relative increase of protein supply required will be less. Thus, Maynard estimates that the maintenance requirement for protein for the cow may be increased during gestation by an average of 17 per cent. over the whole period, or 40 per cent. in the closing stage.

These are probably under-estimates of what is *desirable*, since here again, as also for energy storage, regard should be had to the desirability of enabling the parent to store up a reserve of protein in her body, apart from the bare needs for reproduction, in order to provide some insurance against the drain to which she may be exposed later when the heavy demands of lactation have to be met.

VITAMIN REQUIREMENTS

Despite a considerable amount of research, the precise significance of vitamin supply for reproductive efficiency is still not clearly defined. Only for vitamins A and E does there seem to be a clear case for postulating that the maternal diet must include extra amounts to cover any specific requirement for reproduction. For the welfare of the mother herself the whole range of vitamins may be of importance, and certainly the A and D vitamins, whilst a liberal supply of these vitamins to the mother makes possible the accumulation of reserves in the fœtus, which will be valuable in the early stages of

* This figure agrees well with that of 12·5 grm. obtained by Evans in experiments at Cambridge.

post-natal life. That there is a specific requirement for vitamin D for reproduction would seem probable, but conclusive evidence as to this has not yet been obtained, especially as regards farm animals.

That an adequate supply of vitamin A is essential for efficient reproductive activity has been established for both sexes. In the male a deficiency of this vitamin quickly induces a marked lowering of fertility. In the female the first sign of vitamin-A deficiency is commonly the development of irregularity of œstrus, which ultimately may cease entirely if the vitamin deficiency is very severe. If fertilization takes place, the gestation may be prolonged and terminate in difficult parturition ; the placenta will often be abnormal and the incidence of fœtal death and resorption, or of abortion, will be increased. These effects arising primarily from placental injury are said to differentiate cases of vitamin-A deficiency from fœtal death due to deficiency of vitamin E which is occasioned more directly by defects in the fœtal tissue istelf. The diagnosable symptoms of vitamin-A deficiency vary somewhat according to the species of animal and the severity of the deficiency.

Little is known as to the minimum requirements of vitamin A for reproduction, but there is evidence that they are at any rate greater than those for maintenance. The simplest practical safeguard against deficiency of this vitamin lies in the supply of leafy greenstuffs, either fresh or artificially dried. Where this is not available, or with animals, such as the pig, that can only digest relatively small quantities of roughage, the inclusion of yellow maize in the ration will be helpful. There is evidence, however, that pig-feeding rations, even when relatively large proportions of yellow maize are included, are often barely adequate in supply of vitamin A unless either a store of the vitamin has been built up in the animal during the pre-natal and early post-natal periods, or some additional good source of the vitamin, such as greenstuff or cod-liver oil, is added to the ration. As to the former alternative, experiments at Cambridge and elsewhere have demonstrated that only a very small fraction of the vitamin A of the maternal food-supply can be stored up in the offspring, so that with a rapidly growing animal like the pig the most liberal pre-natal supply of the vitamin to the mother will not for long safeguard the offspring against deficiency in the post-natal food supply.

The basic need for vitamin E for reproductive efficiency has been demonstrated, but there is little evidence as yet that breeding troubles due to deficiency of this factor are met with more than very rarely in farm practice. Nor, indeed, is it to be expected that this class of trouble would be often met with in view of the supply of the vitamin in greenstuffs and the germ of cereal grains. Should the exigencies of flour milling, however, lead to a greater removal of the germ from the " offals " than is as yet customary, the possibilities of Vitamin-E shortage in breeding stock kept indoors with little or no greenstuff or unmilled grain would need to be examined.

MINERAL REQUIREMENTS

The general importance of an adequate supply of mineral elements for the building up of the developing fœtus is obvious. Calcium and phosphorus are essential for bone formation, alkalies for the proper functioning of the body

fluids, iron for the production of the necessary hœmoglobin in the blood, iodine for the efficient working of the thyroid gland, and other mineral elements for other specific purposes. There is little possibility with these mineral requirements of off-setting a deficiency of one element by a surplus of another of similar character, say of potassium by sodium.

For the purposes of energy supply, carbohydrates, fats and proteins are to a large extent mutually replaceable, but in regard to mineral supply the functions in the body of each particular element are largely specific and can therefore only be met by the supply of that element in the food.

Judged in terms of quantity, the most spectacular mineral requirement for growth, and therefore for reproduction, is that for calcium and phosphorus, since these form so large a part of the structure of the bones. The magnitude of this requirement explains also why deficiencies of calcium and phosphorus are more frequently the cause of trouble in practical animal husbandry than any other form of mineral shortage.

The direct incidence of deficiency of calcium or phosphorus on reproductive efficiency has been conclusively demonstrated by experimental work in many parts of the world. As an example, the classic work of Theiler and his associates with cows on the phosphorus-deficient grazing areas of South Africa may be quoted. When the grazing was supplemented by bone meal or other phosphorus concentrates the calf crop was about 60 per cent. greater than when no such supplement was given. Similar effects upon fertility also accompany calcium deficiency, which causes an increase in the number of progeny born dead or weakly.

Over the world in general, calcium deficiency is probably less widespread than phosphorus deficiency, but there are many areas, including a large part of Britain, in which the position is reversed. In housed animals fed mainly on grain and other concentrated foods it is also more often the supply of calcium than of phosphorus that needs special attention.

The effects of shortage of these elements on reproduction are the more insidious through the gradual character of their development, since for a time, which may be prolonged, the deficiencies of the food may be made good by depletion of the supplies of calcium and phosphorus in the maternal skeleton. Even with a continuous deficiency, therefore, little effect may be apparent at the first, or even at the second pregnancy, and when eventually it does appear the general tendency will be to look for the cause in some recent change of diet or treatment rather than in the long-continued (but unsuspected) dietary mistake. The unwisdom of allowing a drain upon the mineral reserves of the maternal body during the gestation period becomes actual folly when it is remembered that this period is followed by the period of milk production, in which for a time some further depletion of the maternal mineral stores is almost inevitable even with a liberal supply of minerals in the food.

It is difficult to arrive at reliable data for the calcium and phosphorus requirements of the pregnant animal since these must cover not only the amounts actually stored in the contents of the uterus but also the maintenance needs of the mother, who should indeed receive more than this in order to

enable her to build up reserves in her bones with which to meet the subsequent strain of lactation. As to the actual storage in the growing fœtus, the data obtained in the American studies with pigs referred to above indicated that about 95 per cent. of the calcium and 90 per cent. of the phosphorus were stored up in the second half of pregnancy, and no less than 60 per cent. and 50 per cent. respectively were stored up in the last three weeks. It would seem, therefore, to be more particularly in the later weeks of pregnancy that attention should be given to the adequacy of the supply of these two mineral elements.* The same applied to the storage of iron, except that in this case the rate of increase of storage increased more gradually from start to finish, although about 80 per cent. of the total was stored in the second half of the period and nearly 40 per cent. in the last three weeks.

In other American studies the conclusion was reached that the ration of pregnant sows should contain not less than 0·4 per cent. of calcium, or say 0·3 per cent. rising to 0·5 per cent., with rather less phosphorus. For gilts the proportion would need to be a little higher to cover the gilt's own growth requirements.

As regards ruminant animals, with their longer period of gestation, the daily requirement of minerals is less in proportion to body size. Thus, in the ewe it is estimated that 0·2 to 0·35 per cent. each of calcium and phosphorus in the daily ration will be adequate. In the cow a still lower proportion, say 0·15 to 0·25 per cent. is probably adequate for maintenance and reproduction, but here the estimation of the requirements for the needs of production is complicated in the first pregnancy by the simultaneous need for the purposes of growth of the heifer, whilst in later pregnancies a still greater complication arises if, as is usual, milk production is continued through the greater part of the new gestation period. In practice, therefore, it is hardly possible or indeed necessary to discriminate between the requirements for the various needs which together make up the total requirements. A rough standard which, judged by American data, will probably not be far wide of the mark for average conditions, can be arrived at by taking a minimum requirement of 0·10 per cent. each of calcium and phosphorus in the dry matter of the food for the "empty" dry cow, increasing this by 0·07 per cent. for the dry, in-calf cow, and by a further 0·07 per cent. for each gallon of milk. On this basis, the cow of average size, in-calf and giving 2 gallons of milk daily would need in her daily ration about 0·3 per cent. each of calcium and phosphorus.

The requirement for other mineral elements need only be dealt with briefly, since it is probably only rarely in ordinary breeding practice that actual deficiency with regard to them arises. It is true, for example, that the need of the pregnant animal for iron is probably twice or thrice as great as the maintenance requirement, but unless the animal is kept under highly artificial conditions, such as are for many reasons undesirable for breeding stock, it is

* On the other hand, results obtained by Evans at Cambridge indicated that, even with a liberal supply of calcium in the food, the enhanced requirements of the fœtus in the later stages of pregnancy were largely drawn from the maternal reserve, so that the wiser plan may be to give calcium liberally in the first half of the gestation period in order to ensure that this reserve is fully developed when it is needed, rather than to rely upon direct assimilation from the food at the time when the need is greatest.

unlikely that even this enhanced iron requirement will not be met by the ordinary food supply. The risk is certainly greater with a prolific quick-growing species like the pig than with slower-growing species, and for the in-pig sow, without any making any nice calculations as to iron supply, it may be worth while to enrich the dietary slightly with iron on the off-chance that some little of it may be stored in the young pigs, which thereby may be better equipped to avoid the post-natal risks of anæmia.

The only other mineral element that perhaps needs special mention is iodine, but as to whether deficiency of this element is likely to be at all common in practice it is difficult to obtain clear guidance. Since iodine is an essential factor in the activities of the thyroid gland, which include an intimate influence upon the processes of reproduction, it is obviously very important that there should be no risk of shortage of iodine in the breeding animal. The evidence from practical feeding experiment with iodine supplements to ordinary rations is very conflicting, and certainly does not as yet warrant any general recourse to iodine supplements for breeding stock. A deficiency of iodine so pronounced as to affect reproduction seriously will almost certainly establish a goitrous condition in the parent animal, and where such condition can be diagnosed an increase in iodine supply is clearly required. In the light of existing information we are inclined to agree with Maynard that " there is no conclusive evidence that the feeding of additional iodine to breeding animals is helpful except in the specific situations where goitre is occurring, or that it has any benefits other than goitre prevention.

. . . . Since the danger of over-dosage with iodine is a real one, it seems wise to restrict its use to the prevention of goitre and related troubles in areas where they otherwise occur, until positive benefits for other purposes have been clearly proved ".

Finally, a word may be said as to the possible need for a supply of salt to the breeding animal. No information is available on this point, but since there is evidence that deficiencies of salt supply may arise in respect of quick-growing animals like the pig and chicken it may perhaps be as well to keep in mind a similar possibility in regard to pre-natal growth, although in this case the maternal body will probably provide an adequate regulator of supply to the uterus even on a salt-deficient diet. It is plain commonsense, however, that a deficiency which can be foreseen should be avoided.

SOME FUNDAMENTAL PRINCIPLES OF EROSION*

IT has so far proved impossible to express the problems of erosion in terms of known physical laws. Hydrauli cengineers have evolved certain empirical rules for its prediction, but these do not appear to have universal application. According to Dr. E. G. Richardson of King's College, Newcastle, England, the chief factors deciding the amount of stream erosion are :—

(*a*) the degree of turbulence of the water,
(*b*) the magnitude of the " gradient of velocity " over the soil surface,
(*c*) the size, shape and density of the soil particles,
(*d*) the compactness of the soil.

The gradient of velocity of a stream or runnel is determined by the change in velocity at increasing distances from the bed ; it is a fundamental factor in the modern theory of stream erosion, and is a more useful conception than mere surface velocity. For a given gradient of velocity, provided a stream is sufficiently turbulent to cause adequate mixing, erosion varies inversely as the size of soil particles having the same density. At increasing distances vertically above the bed within the turbulent stream, the concentration of soil particles (" silt ") diminishes exponentially with the magnitude of the height ; hence the slope of the straight-line graph obtained by plotting heights against logarithms of silt concentrations, furnishes a measure of what may be termed the " coefficient of erosion". Silt concentrations were measured by Dr. Richardson by a photo-electric method applied to graded sands moving under the action of water down glass-sided wooden channels. In this way, experimental evidence was obtained which proved the exponential or logarithmic law.

It has often been reported by hydraulic engineers that *colloidal* particles are less easily eroded than particles of larger magnitude. For soil comprising grains of heterogeneous size, a maximum rate of erosion seems to obtain for diameters around 0.1 millimetre (the " fine sand " grade in soil texture analysis). This apparent anomaly is now explained by the fact that the velocity gradient is not the same in moving water carrying colloidal material as in a homogeneous fluid, or in a stream containing sparsely-distributed particles of relatively large dimensions.

The permeability of a soil to water as determined by its natural structure is the first factor to operate erosion. A highly permeable soil allows water to penetrate easily and so to gain intimate contact with the structure units. If these are unstable or incoherent, readily disintegrating into small discrete grains, then the particles are floated apart, and those lying near the surface

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* By F. H. in the *Tropical Agriculture*, Volume XVI., No. 4, April, 1939.

may be lifted bodily into the stream and rapidly removed. Soils having single-grain structure are thus very prone to erosion, especially if the size of the grain is uniform and small (around 0·1 mm.). If, however, the structure is crumbly and the aggregates are large and stable in water, or if it is coarse and the particles are heavy, then a greater velocity gradient is required to disturb the grains, and the soil strongly resists erosion.

A very deep permeable soil may absorb all the rain that falls on the ground, and eroding streams may fail to develop, but a permeable *shallow* soil, underlain by an impervious bed, readily becomes waterlogged and either slowly moves bodily down hill ("hill-creep"), or rapidly fills with water so that runnels develop over its surface. On the other hand, a fine-textured soil having *low* permeability may permit only the surface layer to become saturated, and streams may develop before downward penetration has proceeded very far. Slow penetration may greatly alter the distribution of velocity near the bed through the successive floating off of soil particles, so that a quasi-solid layer is formed at the surface, and this may diminish the load that can be carried in suspension.

Application to Customary Methods of Erosion Control.—One of the chief methods advocated for controlling erosion is to reduce the overall slope of the land by constructing terraces, or by creating barriers of vegetation. These procedures would seem to be merely palliatives. Although a reduction in the angle of slope over the surface of a terrace may be very effective in minimizing erosion, the water-level may rise rapidly during rains, so that, unless the soil is very permeable and deep, the land may become waterlogged and de-aerated. In extreme cases, the waterlogged soil may slip and break down the terrace, spilling water onto the lower grounds. Hence, *in regions of heavy rainfall, terracing should be practised with great caution*, and in all cases provision should be made for the adequate drainage of the tiers, especially when the soil is not very absorptive. Such modification of the terracing system, namely, the provision of drainage and run-off from the backs of the terraces, greatly complicates their construction, and necessitates careful planning over large areas within which outlet channels for the terrace drains must be accommodated.

As Dr. Richardson points out, a much more satisfactory procedure would be the provision of barriers which *reduce velocity gradients while not unduly impeding the run-off*. In the case of large rivers, this object has been achieved by constructing a series of transverse check-dams or shallow weirs placed at short intervals over the bed. These reduce water-movement over the bed almost to a standstill, yet do not retard the main flow. Application of the same principle to the control of sheet erosion on agricultural lands suggests the close sowing of low-growing herbage which will impede the immediate flow of surface water within, say, an inch of the surface while not hindering the run-off of the bulk of the water. In stony land, a similar result might be attained by placing small boulders in rows at intervals across the slopes, and in land being cleared of forest for agricultural utilization, thin logs of wood or stems of bamboo might be used for providing shallow barriers, at least until the slopes have been stabilized by the establishment of some permanent system of agriculture.

ROOT STIMULATION BY "HORMONES"*

Introduction.—Hormones are peculiar chemical substances produced in certain specialized cells or tissues or glands of all living things, both animals and plants. Not much is known about them, but it already seems evident that they determine and regulate all physiological processes. The name "hormone" means "I arouse to activity" or "I stimulate". Hormones may thus be likened to chemical "messengers", transmitting orders to various parts of the body of the animal or plant and thus determining its progress in life. They are *not* nutritional, and must not be regarded as substitutes for food or manure. They are built up by the organism from the food it consumes. Hormones, or substances which appear to serve the same purpose, can now be made artificially in chemical laboratories. Such artificial or substitute hormones may have valuable properties when skilfully applied. They may also be dangerous, as when for example they are put into some of the quack medicines sold for "rejuvenating" or "slimming".

This does not seem to have any connection with rubber planting. Actually it has, because substances of the hormone type can now be used for treating stumps before planting in the field. This treatment greatly stimulates root formation and thus reduces the risk of stumps dying. If the treatment proves as successful as the early experiments indicate, one of the chief objections to planting budded stumps will be removed. This may be a great advantage, since if budded stumps could always be planted successfully, instead of the more usual practice of planting seeds and budding a year later in the field, valuable time would be saved in bringing an area into tapping.

Before discussing this and other possible uses of hormones in rubber planting, a brief account of the discovery and development of these substances may be of interest.

History of Hormones.—Growing plants bend towards the light. This has always been common knowledge, and apparently nobody tried to explain it until Darwin in 1882 suggested that the growing tip transmitted some influence along the shaded side of the plant. This was proved 40 years later when it was shown that the influence was a chemical one caused by a growth-hormone formed and secreted by the tip. Plants bend towards the light because more of the growth-hormone is sent to the shaded side than to the illuminated side, and so the shaded side grows faster.

Sachs, also in 1882, suggested that there was a special root-forming substance which plants prepared in their leaves and sent down to the roots. If the stem

* Reproduced from *The R. R. I. Planters' Bulletin*, No. 4, June 1, 1939, Rubber Research Institute of Malaya, Kuala Lumpur, F. M. S.

of a plant is ring-barked under suitable conditions roots may be formed above the ring where the downward movement of the root-forming substance is interrupted. Similarly, abnormal swellings called "galls", which occur on various parts of plants and animals, were thought by Beijerinck in 1888 to be caused by stimulating substances which he named "growth enzymes" because, like chemical enzymes, very small amounts could cause great changes.

In 1916, Loeb found that shoots of certain plants would take root more easily if they were bearing leaves and active buds than they would if stripped, suggesting that root formation is caused by hormones produced in leaves and buds. This was confirmed several years later by Went at Buitenzorg, Java, who showed that cuttings from which the leaves and buds had been removed would take root if the upper ends were treated with a water extract of the leaves. Normally such cuttings would form few or no roots.

It is impossible to describe here in detail the work on hormones done during the last ten years. Knowledge is increasing rapidly, and hormones have been found in various parts of plants and animals. The term "hormone" is often used rather loosely, to include artificial as well as natural substances. Other names in common use are plant hormone, phytohormone, growth substance, growth regulator, "Wuchstoff", and auxin.

Synthetic Auxins.—In 1931, Kögl, Haagen Smit, and Erxleben isolated three distinct hormones or "auxins" in pure form. One of them, called "hetero-auxin", is produced by fungi and bacteria. It was analysed and found to be indole-acetic acid. This is produced by the decomposition of proteins and had been found in human urine as early as 1885. In 1925 Majima and Moshino synthesized it, and now it and similar synthetic substances are widely used in horticulture as plant stimulants. They have been tested in many places and on many types of plants, and several satisfactory proprietary solutions of these auxins, or artificial-substitute-hormones, are offered for sale under various trade names.

Work at the R. R. I.—Three possible ways of using these growth-substances or auxins in rubber growing have been studied at the Rubber Research Institute. They are :—

(1) Application to the tapping panel, to stimulate bark renewal.

(2) Treatment of cuttings of young rubber seedlings, in the hope that rubber cuttings can be made to take root so that valuable stocks may be multiplied quickly in this way.

(3) Treatment of stumps for planting, in order to hasten the formation of roots and thus reduce the risk of loss due to drought or other unfavourable conditions.

So far little information of practical importance has been obtained from the treatment of tapping panels and of rubber tree cuttings, but the treatment of stumps for planting has given very promising results. Experiments were carried out to compare treated and untreated stumps. All were planted in the

field under the same conditions, and stumps of each set were dug up after varying periods and examined. Some of the earlier results are as follows :—

(*a*) Stumps dug up and examined *one month* after planting—

	Total No. of Stumps.	No. that had taken Root.	Total No. of Roots.
Treated	11 ..	7 ..	67
Untreated	11 ..	3 ..	4

(*b*) Stumps dug up and examined *two months* after planting—

	Total No. of Stumps.	No. that had taken Root.	Total No. of Roots.
Treated	15 ..	15 ..	98
Untreated	15 ..	10 ..	36

These results show that stumps treated with suitable growth-substances take root much more quickly and produce many more roots than do untreated stumps. Other figures not given here suggest that the growth of the shoots may also be better on treated stumps, as one would expect, but further work is needed to make sure of this. It is not yet known whether the treated stumps will continue to grow more vigorously because of their better start in life, but there is no doubt that the treatment will reduce the risk of loss during the first few months. This is an important point, since the risk of loss in planting budded stumps on inland soils has hitherto been very high.

When the larger-scale experiments now in progress have gone far enough, a full account with detailed figures will be published in the R. R. I. Journal. Meanwhile, the following method of treating stumps before planting is recommended.

Method of Treatment.—The stumps are pulled up, washed free of soil, and trimmed. The tap root is pruned with a slanting cut, about 18 inches below the collar. Small lateral roots are cut off entirely, and large laterals are pruned to 3 inches. Latex from the cuts is peeled off before treatment. The stem should be trimmed at the same time as the roots. If the stumps are budded stumps which have been cut back in the nursery a few days before pulling, another ½ inch at least should be cut off the top of the stock. This is to give a fresh open end to the stem, otherwise the root will not readily absorb the solution.

The treatment consists of allowing the freshly-trimmed stumps to stand for 16 to 24 hours with the cut ends of their tap roots in a dilute solution of the growth substance, a synthetic auxin or hormone. The strength of the solution is as recommended by the makers. The solution should be about 1½ inches deep, so that it covers the cut. A suitable container is a coagulating tank, which for convenience of packing the stumps may easily be divided into compartments by its partitions.

After treatment the ends of the roots are washed in water, the cut ends of the stems dipped in just-melted budding wax, or painted with a good white paint, and the stumps planted in the usual way.

Two suitable growth-substances for treating stumps are now available in Malaya. They are " Hortomone A " and " Seradix A ", both sold with full directions for use. Used as directed, the cost of treatment is less than one cent per stump for small stumps, rising to three or four cents for large stumps with their lateral roots not closely trimmed. This works out at roughly $2 to $8 per acre which, it is hoped, will be amply recovered by having fewer stumps die, quite apart from the possibility of permanently better growth of the treated stumps.

REVIEW

ANNUAL REVIEW OF BIOCHEMICAL AND ALLIED RESEARCH IN INDIA, VOLUME IX, 1938

THE ninth volume of the " Annual Review of Biochemical and Allied Research in India" published by the Society of Biological Chemists, Bangalore, India (Price Rs. 3 or 6 sh.), maintains the high standard of its predecessors and is of undoubted value and utility to research workers in agriculture and the biological sciences. It contains reviews by various authorities on thirteen subjects among which the following may be mentioned as being of more direct interest to local agriculturists and agricultural scientists : Foods and Nutrition ; Soils, Fertilizers and Manures ; Chemistry of Plant Products ; Animal Nutrition and Dairying ; Plant Physiology ; Microbiology and Fermentation ; and Phytopathology—Mycology and Entomology.

Much research has been conducted in India within recent years on the subject of foods and nutrition, the results of which are of considerable interest and importance to Ceylon. The year under review has been one of marked fruitfulness in this field of work. Of interest are the following facts : Par-boiled rice is superior in many respects to raw rice, *e.g.*, with the same degree of milling, par-boiled rice is richer in nitrogen and phosphorus than raw rice ; par-boiled rice, whether polished or unpolished, loses on washing less nitrogen and phosphorus than comparable samples of raw rice ; coloured and coarse-grained varieties of rice are richer in proteins and minerals, particularly phosphorus, than fine-grained varieties ; polishing results in the loss of about 30 per cent. of the fat, 25 per cent. of the proteins and 50 per cent. of the ash of the rice grain. (Similar results were obtained locally with Ceylon rices) ; the vitamin A content of ghee is dependent on its degree of acidity—the lower the acidity, the greater being the vitamin A content.

In the section on Microbiology and Fermentation, due consideration is given to the much-debated question of the effects of sunlight on nitrogen metabolism in the soil. The review of plant physiological research contains some interesting information in regard to the germination capacity of rice seed under different conditions. The following interesting facts have emerged from this investigation : (1) Seed stored in galvanized iron bins maintains its vitality better than that stored in gunny bags, (2) the highest percentage and quickest germination are obtained by soaking rice seed for 12 hours, (3) rice seeds germinate well under mud to a depth of 1–2 inches but the seedlings have difficulty in penetrating through more than two inches of mud. The main features of the section on soils, fertilizers and manures are the accounts of advances in soil physics and

chemistry, soil erosion, soil nitrogen, composts, and the manuring of rice, sugar cane and other crops. Reference is made to the work of De and Fritsch on the fixation of nitrogen by algae under water-logged rice soil conditions. The sections on phytopathology are of special interest to local agriculturists as they deal with a number of crops grown in Ceylon. The chapter on animal nutrition and dairying furnishes useful information to cattle breeders and dairy farmers in India and Ceylon.

The Editors are to be congratulated on having placed at the disposal of those interested in recent developments in agricultural and biological science in india a compendium of 150 pages, many of which contain information worth appreciably more to them than the price of the book. Author and subject Indexes are appended.

A. W. R. J.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED JUNE 30, 1939

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1939	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Haemorrhagic Septicaemia	3	3	3	..	..	..
	Piroplasmosis	3	1	..	3	..	..
	Rabies	2	..	..	..	..	2
	Blackquarter	1	..	1	..	..	..
	Rinderpest	9	..	..	2	..	7
Colombo Municipality	Foot-and-mouth disease	27	2	2	22	2	1
	Anthrax	1	..	1	..	..	..
	Rabies	2	..	2	..	..	..
	Piroplasmosis	5	..	..	5	..	..
Cattle Quarantine Station	Foot-and-mouth disease	2	..	..	2	..	..
	Anthrax	29	..	29	..	..	..
Central	Foot-and-mouth disease	137	..	..	137	..	..
	Anthrax	3	2	3	..	..	..
	Rabies	8	..	2	..	..	6
	Piroplasmosis	9	4	1	6	2	..
	Contagious mange	18	..	2	16	..	..
	Blackquarter	8	..	8	..	..	..
Southern	Foot-and-mouth disease	65	50	..	60	5	..
	Haemorrhagic Septicaemia	4	..	4	..	..	..
	Rabies	1	..	..	..	..	1
Northern	Foot-and-mouth disease	130	..	7	123	..	..
Eastern	Foot-and-mouth disease	5	3	..	5	..	..
North-Western	Foot-and-mouth disease	122	..	3	119	..	.
	Rabies	3	1	..	..	..	3
North-Central	Foot-and-mouth disease	1,666	305	10	1,351	305	..
Uva	Foot-and-mouth disease	101	11	4	74	23	..
Sabaragamuwa	Haemorrhagic Septicaemia	1	..	1	..	..	..

Department of Agriculture,
Peradeniya, July 17, 1939.

M. CRAWFORD,
Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, JUNE, 1939

Station	Temperature				Humidity		Amount of Cloud	Rainfall		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	85·2	0	77·6	+0·4	81	86	8·4	6·25	22	— 2·73
Puttalam ..	86·1	0	78·7	—0·3	79	86	7·6	0·63	6	— 1·04
Mannar ..	87·4	—1·0	80·6	+0·1	76	82	9·0	0	0	— 0·50
Jaffna ..	86·4	+0·1	81·0	+0·4	79	80	5·2	0·01	1	— 0·39
Trincomalee ..	92·2	+0·4	79·1	+0·4	60	78	6·8	0·34	3	— 0·74
Batticaloa ..	92·4	+0·3	77·8	+0·5	62	80	5·4	0·26	3	— 0·75
Hambantota ..	86·9	+0·4	77·1	+0·4	77	89	6·2	1·45	10	— 0·78
Galle ..	83·1	—0·5	77·6	+0·4	82	86	7·1	6·67	20	— 2·01
Ratnapura ..	85·9	—0·6	74·6	+0·1	81	93	7·4	19·31	26	+ 0·27
Anuradhapura ..	88·4	—1·0	75·8	—0·4	69	91	6·8	0·11	3	— 0·83
Kurunegala ..	85·9	—0·7	74·9	—0·4	78	90	7·6	7·45	23	+ 0·06
Kandy ..	82·6	—0·6	70·5	—0·7	76	87	8·7	8·22	23	— 1·36
Badulla ..	85·0	—0·4	65·9	+0·7	64	89	5·4	0·95	7	— 0·84
Diyatalawa ..	77·2	—0·6	63·2	+0·4	65	82	6·8	4·53	11	+ 2·76
Hakgala ..	68·5	—0·7	57·8	—0·4	78	86	6·6	6·66	21	— 0·32
Nuwara Eliya ..	65·4	—0·7	55·4	0	85	88	9·1	9·91	27	— 1·03

The rainfall for June was below normal over the greater part of Ceylon, the only appreciable areas showing excess being the Uva plateau and the south-eastern edge of the hill-country, and the Ginigathena Pass and neighbouring districts, while a few stations in the Southern Province, and near Trincomalee and Tirrukovil, also showed excess. The greatest excesses recorded were 6·05 inches, at Matara Hospital, 5·83 inches, at Padupola, and 5·63 inches, at Bibile, while at most of the stations reporting excess, that excess was less than 2 inches. The greatest deficit was 5·18 inches, at Yatiyantota, while a number of other stations, mainly in the hills or in the low-country to the west of them, reported deficits of 2 to 5 inches.

The highest monthly total reported was 42·48 inches, at Norton Bridge, while totals of over 30 inches were also reported from Blackwater, Kenilworth, Padupola, Theydon Bois, Watawala, Ingoya, Dabar, Carney, and Maliboda.

Most of the stations in the Northern Province reported no rain at all during the month. Other rainfall stations in the dry zone usually reported monthly totals of less than 2 inches, but very few reported no rain at all.

Only four daily falls of 5 inches or over were reported during the month, all on the 4th or 5th. The highest was 6·59 inches, at Carney, on the 4th.

The weather continued to be of the usual south-west monsoon type throughout the month, with south-westerly barometric gradients, winds generally south-westerly, and rainfall mainly confined to the south-western low-country and the hills. The rainfall generally, in these districts, was moderately heavy on the 4th, 5th, 9th 18th, 21st, 27th, 30th, and on other days only light.

Day temperatures were generally a little below normal, except along the east coast, where they were slightly above average. Night temperatures were, on the whole, above normal. Humidity was generally a little above normal by day, and about normal at night. Cloud was mainly in excess. The barometer was above normal. Winds at the coast were, on the whole, above normal, while their directions were generally south-westerly or west-south-westerly. Some high winds were reported up-country.

Hailstorms were reported from Diyatalawa and Ella on the 3rd, and from Ella on the 4th

H. JAMESON,
Superintendent, Observatory.

3——J. N. 85271 (6/39)

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EDITORIAL

PESTS AND DISEASES OF PLANTS

THE more rudimentary biological species, the bacterium, the fungus, and the insect are formidable enemies of agricultural man. In terms of money the annual loss of crops caused by these agents is estimated at several hundred millions of pounds. Human industry proceeds on the basis of a normal balance of forces in the farmer's favour in the same manner as the retail trade survives bad debts. Sometimes Nature's balance is disturbed by causes which are obscure, and an economic crop is faced with complete or partial ruin. The coffee leaf disease in Ceylon of the early eighties was a case of this kind ; the Panama disease of bananas in Central America was another ; a third was the potato blight which, in the middle of the last century, reduced the Irish peasant to practical starvation ; and everybody is familiar with the periodical devastation of crops by locusts in Africa. The memory of these catastrophic experiences makes the farmer very apprehensive when a new disease appears or an old disease assumes epidemic proportions. Considerable uneasiness has been caused amongst the local agricultural community during the last two years by the appearance of *Phloem necrosis* in tea, the unusually acute and widespread incidence of oidium in rubber, the sustained virulence of the infestation of the coconut palm by the species of *Phytophthora* which causes the decay and fall of immature nuts, and the complete denudation of the fields of young paddy by the leaf-eating caterpillar (*Spodoptera mauritia*). Less spectacular (but equally effective in destroying the fruit of human industry) have been the increased activities of the *Agromyza* in beans, of a fly of the genus *Dacus* in all varieties of cucurbits, of the common fruit-fly in oranges, and of the caterpillar *Margaronia caesalis* in jak fruit. There is evidence of strong public feeling that in all these cases the entomologist and the plant pathologist could do much more than they have done. It would be instructive to examine in some detail the strict limits which Nature and circumstances set to their work.

CORRIGENDUM

The total annual consumption of quinine in Ceylon is approximately 29,000 lb. and not 17,000 lb. The other figures in this article derived from the statement of consumption should be similarly amended.

Editor, *The Tropical Agriculturist.*

The

Tropical Agriculturist

August, 1939

EDITORIAL

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THE more rudimentary biological species, the bacterium, the fungus, and the insect are formidable enemies of agricultural man. In terms of money the annual loss of crops caused by these agents is estimated at several hundred millions of pounds. Human industry proceeds on the basis of a normal balance of forces in the farmer's favour in the same manner as the retail trade survives bad debts. Sometimes Nature's balance is disturbed by causes which are obscure, and an economic crop is faced with complete or partial ruin. The coffee leaf disease in Ceylon of the early eighties was a case of this kind ; the Panama disease of bananas in Central America was another ; a third was the potato blight which, in the middle of the last century, reduced the Irish peasant to practical starvation ; and everybody is familiar with the periodical devastation of crops by locusts in Africa. The memory of these catastrophic experiences makes the farmer very apprehensive when a new disease appears or an old disease assumes epidemic proportions. Considerable uneasiness has been caused amongst the local agricultural community during the last two years by the appearance of *Phloem necrosis* in tea, the unusually acute and widespread incidence of oidium in rubber, the sustained virulence of the infestation of the coconut palm by the species of *Phytophthora* which causes the decay and fall of immature nuts, and the complete denudation of the fields of young paddy by the leaf-eating caterpillar (*Spodoptera mauritia*). Less spectacular (but equally effective in destroying the fruit of human industry) have been the increased activities of the *Agromyza* in beans, of a fly of the genus *Dacus* in all varieties of cucurbits, of the common fruit-fly in oranges, and of the caterpillar *Margaronia caesalis* in jak fruit. There is evidence of strong public feeling that in all these cases the entomologist and the plant pathologist could do much more than they have done. It would be instructive to examine in some detail the strict limits which Nature and circumstances set to their work.

It is practically impossible to eradicate a disease that has become endemic in a country. The most illuminating demonstration of the truth of this proposition is provided by the analogous case of human diseases and pests. It is not claimed that endemic human diseases such as influenza, measles, tuberculosis and malaria, or vermin like the louse and the bug, can be eradicated. If they can be, considering the value that the world places on human health and well-being, the world would by now have rid itself of these enemies. So it is with the diseases and pests of plants. The human analogy may be pursued in a consideration of the methods, falling short of complete eradication, that may be adopted in dealing with them.

In the case of the human being, we try to—

(1) keep disease out of a country by strict quarantine,
(2) cure the affected individual by personal treatment,
(3) immunize the individual by inoculation,
(4) prevent the spread of infestation by (*a*) segregation of the infected individual (*b*) personal and communal sanitation.

It is obviously the duty of the scientist to make himself familiar with the symptoms of disease or with the features which establish the identity of insect pests and by the establishment and enforcement of quarantine, to assist the community to prevent, the introduction of new diseases and pests from an infested country to a free country. This function is universally recognized and practised. The cure of the affected individual is impracticable in the case of the plant chiefly because the expenditure of money and effort in cure must never exceed the market value of the cured plant. Inoculation is a young science even in human diseases. Perhaps one may some day discover a method of immunization by inoculation from such diseases as the citrus canker and the leaf spot of betel. But the world is still remote from such discovery. Segregation of growing plants is ruled out by their anchorage to one spot, although the destruction of the affected individual, locally known as the "cut and burn method",—a form of remedy which is not available in the case of the human being—may take the place of segregation. There remains the sanitary method. But that is not a matter for the expert any more than keeping lice off one's head or bugs off one's bed is a duty of the doctor. The scientist should discover by research the vulnerable points in the life histories of insects and broadcast the information—that, for instance, by frequent turning of the manure heap the coconut grower reduces the beetle attack on his palm or that by the application of a film of sulphur dust to new foliage the incidence

of oidium can be reduced—and he may organize demonstrations and, by their means, create a temporary form of mass enthusiasm, even of mass hysteria; but sustained interest in sanitation must be born within the individual.

There are two lines of investigation and of application of scientific method specially available to the plant pathologist and the agricultural entomologist. In most species there are individual plants which are immune to some diseases. It is possible to select these resistant plants and by selection and inter-breeding to fix, in what will be a new variety, those characteristics which give the immunity. This is very important work for the plant pathologist and to do it efficiently he must be not only a pathologist but a botanist, a geneticist and an agriculturist as well. The entomologist can take advantage of the mutual predacity of insects themselves. Some organisms are parasitic in some stage of another. In the case of indigenous pests, the parasite is generally there and Nature establishes its own working equilibrium. For example, the coffee berry borer (*Stephanoderes hampei*) is present in the African colonies, but the *Prorops nasuta* controls it by parasitism and, in the result, the coffee grower saves a reasonable proportion of his crop. In these cases the entomologist must advise and assist the public to recognize and nurse its ally. In the case of a recently-introduced pest his responsibility is more direct and his work more effective. He can seek out the natural enemy of the pest in its country of origin and establish it in the new home of the insect. These are the limits of achievement which are open to the scientist. Those who expect more from him court disappointment.

Note by the Editor.—The Editor regrets that in the Editorial of the June, 1939, number of *The Tropical Agriculturist* the total annual consumption of quinine in Ceylon was given as 17,000 lb. when in fact it was 29,000 lb. A correction slip is issued with this number and subscribers are requested to affix it at the appropriate place in the Editorial.

A STUDY OF THE METHODS OF CULTIVATION OF FRUIT TREES WITH SPECIAL REFERENCE TO CITRUS, PART II., IRRIGATION

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THE manner in which irrigation water penetrates and spreads in the soil was briefly discussed in Part I. of this study (*The Tropical Agriculturist,* Vol. XCII. No. 1, January, 1939). Further discussion on the phenomenon of water movement in the soil is necessary before we proceed to discuss the methods of the application of irrigation water.

In connexion with general irrigation practices we often see special terms used such as " under irrigation " and " over irrigation " to signify certain amounts of water applied to the soil to meet the varying needs of trees in different seasons. For example the term " under irrigation " or " light irrigation " is often used to convey the idea that the moisture content of the soil mass occupied by the roots of the trees will be raised to a certain percentage by the application of small amounts of water because of the downward capillary movement of the water with a consequent equalization of the moisture content of the whole soil mass. This belief is erroneous. According to Veihmeyer (2),* when water is applied to a soil the latter is moistened to its fullest capacity to a definite depth. All attempts by Veihmeyer to maintain a soil moisture percentage less than that which the soil would hold against the force of gravity, which is the maximum capillary capacity, have met with failure. This maximum amount of water held in the soil after the excess gravitational water has drained away and after the rate of downward movement of water has materially decreased is termed the " field capacity " of the soil.

In view of Veihmeyer's investigations, therefore, smaller amounts of water will wet a soil to its field capacity to a smaller depth while larger amounts will wet it to a larger depth. Hence a light irrigation wets a shallow depth of soil to its field capacity while a heavier irrigation will wet a correspondingly greater depth also to its field capacity.

* Numbers refer to references on page 75.

Once the soil attains its field capacity the moisture remains stationary and is not able to move appreciably in an upward or lateral direction from the moist layers of the soil to the drier ones unless the permanent water table exists within 6 to 10 feet of the ground surface. Accordingly, in the absence of a standing water table, if the irrigation water wets only a part of the root zone to its field capacity the roots in the wetted area alone will be benefited while the roots outside the wetted zone will suffer.

In true irrigation terminology, a tree is said to be over irrigated when enough water is applied to cause percolation below the roots or when the applications are so frequent as to affect aeration of the soil.

The absorption of a certain quantity of water by the tree is determined by its leaf surface and weather conditions irrespective of the kind of soil on which it grows, the soil merely serving as a reservoir from which water is extracted by the plant in accordance with its needs. Since light soil has a low water-holding capacity, its supply of moisture is more quickly exhausted than a heavier soil with a higher water storage capacity. Consequently irrigations on light soils should be lighter and more frequent. The amounts of water used by plants of the same species and of similar leaf area under the same climatic conditions are precisely the same whether growing on light or heavy soil. The amount of water to be applied at each irrigation varies with the type and depth of soil to be wetted and the moisture content at the time of irrigation. Thus it will be seen that the data obtained regarding the amounts of water to be applied to a citrus grove under one set of climatic and soil conditions cannot be made use of universally and that every important citrus area in Ceylon will have its own irrigation problem to be individually investigated. In the absence of elaborate investigations on the subject, the writer is of opinion that it would be easy for any intelligent grower to work out fairly accurate data of water requirements for his own grove if he finds out first to what depth the roots of his trees have penetrated into the soil. After ascertaining this the next step would be to find out how much water is needed to penetrate to the full depth of soil which accommodates the roots. This can be done by adding varying quantities of water to several trees selected at random in different parts of the orchard. Finally, the penetration of water into the soil can be observed by digging a trench by the side of the irrigation bed twenty-four hours after the application of water which is the time taken by the majority of our well-drained soils for the gravitational water to drain, stabilize and cease to spread further in the soil.

The irrigation bed should be as large as the spread of the tree crown so that the observation trench falls a little outside the

drip of the tree. The grower need not apprehend any damage to trees resulting from the cutting of roots by trenching beyond the drip. These roots are thin and fibrous and soon regenerate and multiply profusely when the trench is refilled. In fact, pruning of roots in this manner once in about five years improves the bearing capacity of citrus trees.

The observations on the movement of irrigation water are best carried out during a long spell of dry weather when absolutely no rain is expected. The soil before irrigating should be thoroughly dried out by withholding water from the trees for a long time so as to cause slight curling of their leaves. The curling of leaves in the case of citrus is an indication that the soil of its main root zone is thoroughly dry and is about to exhaust its store of available water. It is at this dry stage that the soil is capable of showing its full capacity for wetting to a definite depth under the influence of a given amount of water. Observations made by irrigating a moist soil, that is when it is already at a higher water content, will not be of any practical use. In a moist soil it may not be easy to discern distinctly the line dividing the wetted and unwetted portions of the soil such as will be clearly seen when a dry soil is wetted.

The soils are most economically irrigated when they are fairly dry. There is no advantage in applying water to soils when they are already wet as the greater part of it merely percolates downwards and is lost.

The method of irrigation is governed by the topography of the land and the supply of water, and must be so arranged as to guarantee uniform distribution and penetration of water to all parts of the root system. Flood, basin, ring and furrow methods of irrigation with their various modifications have been long practised with varying degrees of success in different parts of the world but none of them can be singled out to be the best for all conditions.

Uncontrolled flooding of large pieces of land is to be generally condemned as an orchard practice. Orchards planted on sandy and similar light soils should not be flood irrigated as these soils have a tendency to take too much water at the upper head. Flooding is generally used in the case of alkali soils to leach the harmful salts from the root zone of the trees. Flooding is also useful in destroying termites especially in the soils of tropical countries having long spells of dry weather. Except under special circumstances, therefore, flooding should be avoided as a method of irrigating orchards. It is not only a wasteful practice but it also destroys the porosity of clay and of fine-textured soils as explained later in this article.

The most common method employed in the dry zone of Ceylon as well as in India is to irrigate in a small square or circular

shallow basin about 6 to 9 inches deep and approximately as wide as the spread of the tree branches. In areas where the underground water supply is scarce and water has to be lifted from great depths, the dimensions of the irrigation bed are reduced to any convenient size to suit the quantity of water desired to be given to each tree. In this system of irrigation, when the tree is young, the part of its root system beyond the water basin, which corresponds to the drip of the crown, suffers from lack of water for nearly eight months of the year except during the monsoon when all the root-spread is uniformly wetted. However, in a closely-spaced citrus plantation (14 feet) of an advanced age (10 to 20 years) where tree branches touch one another and the water basins are correspondingly enlarged to the full spread of the tree crown, the entire orchard space gets wetted.

The basin system, which is in other words flooding in small compartments, is quite a convenient and efficient method of irrigation on flat lands where water is available in limited quantities and the soil is fairly coarse-textured, absorptive and well drained. But this system has been found unsuitable for fine-textured soils just as has the large scale flooding referred to above. As far back as 1910, Howard (1) in India pointed out the danger of injury to the physical texture of fine-textured soils of Pusa by surface flooding in basins. Flooding in basins, or otherwise, destroys porosity and the surface soil easily runs together. Especially during the dry, hot weather, irrigated land, if it is silty, sets on the surface into a cement-like mass which rapidly loses its moisture. This packing cuts off the air supply to the surface roots and the trees begin to look unhealthy. In order to obviate the evil effects of packing, Howard (2) advocated a sort of furrow-ring system which consisted of surrounding each tree (peach) with a ring (circular trench) 9 inches wide and 6 inches deep, the position of the ring corresponding to the outer spread of branches. It may be pointed out here that in this furrow-ring method, the part of the root system of the tree accommodated in the soil below the ring only could be benefited by the irrigation water. Water impounded for a few minutes in a 6-inch deep trench will not appreciably move sideways into the soil and hence will not wet sufficiently the lateral root-spread of the tree situated at a distance on either side of the circular trench.

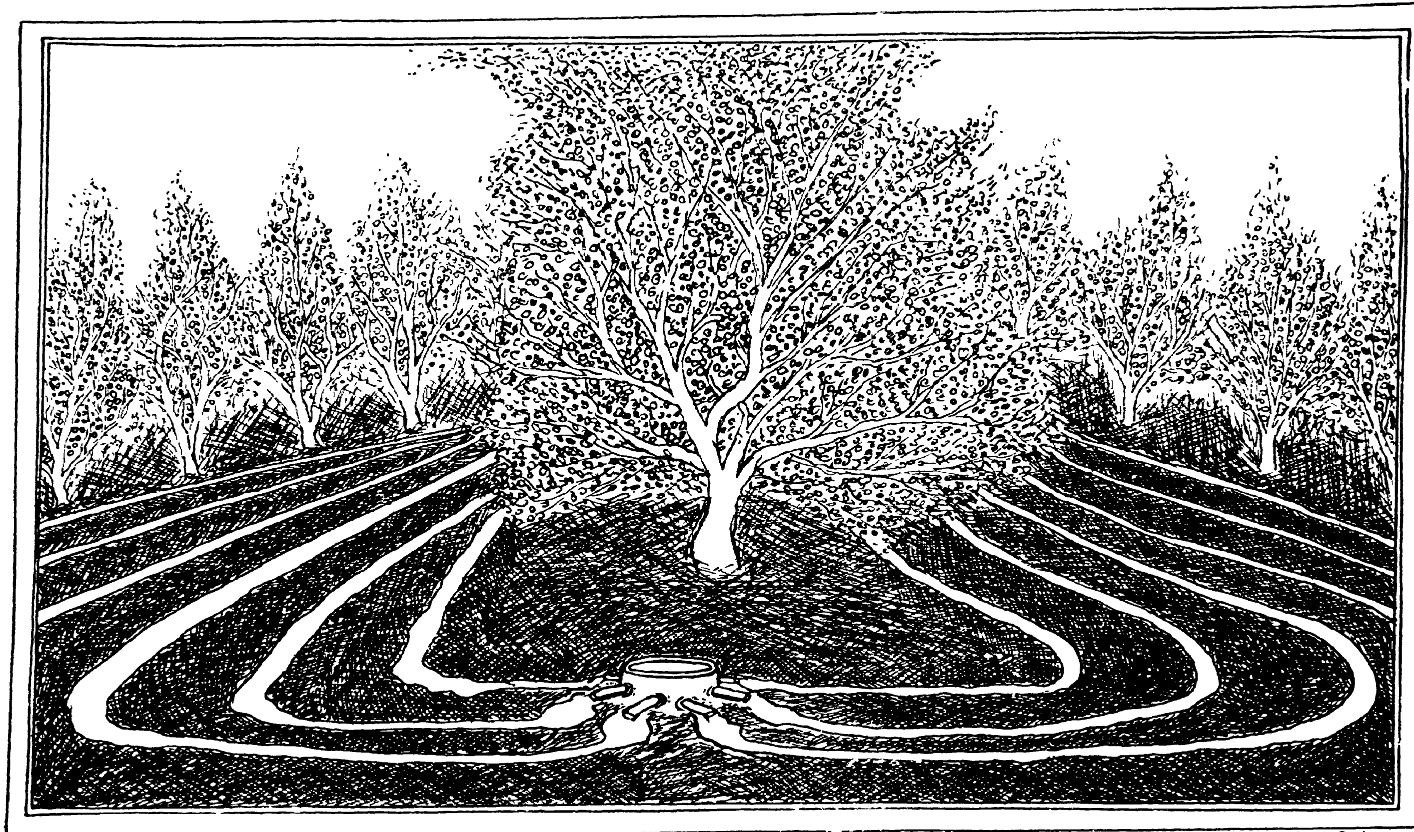
Besides the disadvantages mentioned above, the main drawbacks of both the basin and the furrow-ring systems are the cost of preparation of basins and of rings and the subsequent cultivation to keep out weeds which involves a good deal of manual labour.

The outstanding method which has largely influenced our present ideas of orchard irrigation, is a sort of furrow irrigation

as universally practised in citrus orchards in Southern California, U. S. A., and adopted recently with various modifications in other citrus growing countries such as South Africa and Palestine. This furrow irrigation (Fig. 1) is managed by means of a system of underground pipes, concrete hydrants and regulating valves. Shallow furrows about 6 to 9 inches deep and 2 feet wide are drawn beyond the drip of the tree crown and between rows of trees. The flow of water is so regulated by means of a valve fixed in the hydrants as to control its very gradual seepage into the sides and the bottom of the furrows. The application of water in this manner by means of a slow, trickling, continuous flow from the hydrant over a fixed period, varying from 24 to 48 hours according to the soil, is found sufficient for completely wetting the required volume of soil containing the entire root system of the tree.

To adopt any such system in which a measured quantity of water is made to run in a continuous flow by means of mechanical devices such as those mentioned above would be at present too expensive and impracticable under Ceylon conditions. However, a method to be hereafter called " Cross furrow-basin " system in which water is impounded for a few minutes as in the ordinary basin method offers an improvement on the present practices of cultivation and irrigation in Ceylon. This method was successfully adopted by the writer for citrus trees at the Ganeshkhind Fruit Experiment Station in India and is described below so that it may be given a trial by those working under more or less similar conditions in the dry zones of Ceylon.

The cross furrow-basin system of cultivation and irrigation (Fig. 2) consists of planting young fruit trees so wide apart as to give reasonable space for roots to spread naturally, to admit full sunshine all around the tree, and to leave sufficient space between trees when fully grown for cultivation to be done by bullock-drawn implements. For the first two or three years of the life of the tree it is basin-fed as the root system has not sufficiently advanced to justify the making of furrows by means of bullock-drawn implements. The basin made is so large as to irrigate the area of the soil about two feet wider than the root-spread of the tree. Commencing from the fourth year the cultural treatment consists of cultivating the soil and preparing irrigation furrows beyond the drip of the tree crown and as far as the roots have spread. The basin underneath the crown is made, as usual, as large as the branch-spread, whilst the root space beyond on all four sides of the tree is divided into closely-spaced cross furrows by means of a small home-made ridging plough (Fig. 3) worked by a single pair of bullocks. Prior to making furrows, farm yard manure is broadcast and the land is ploughed and harrowed about six inches deep so as to have



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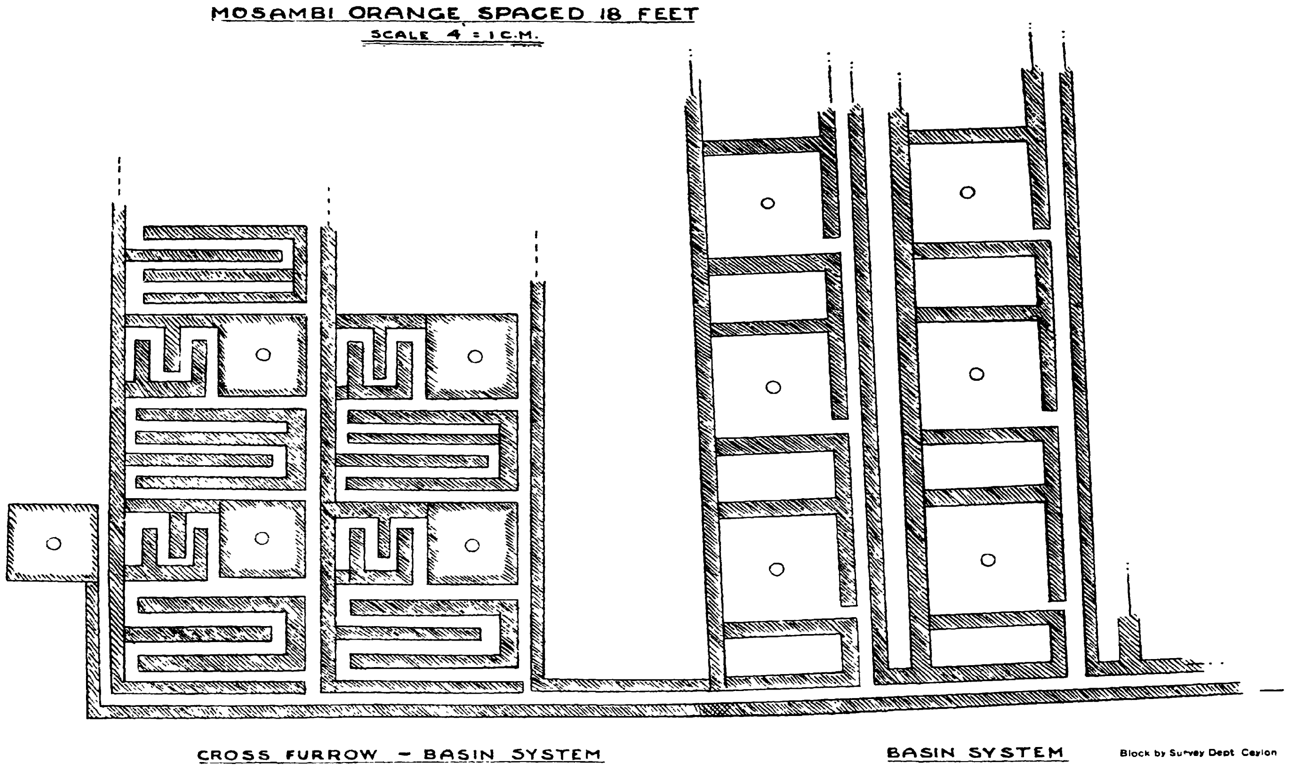
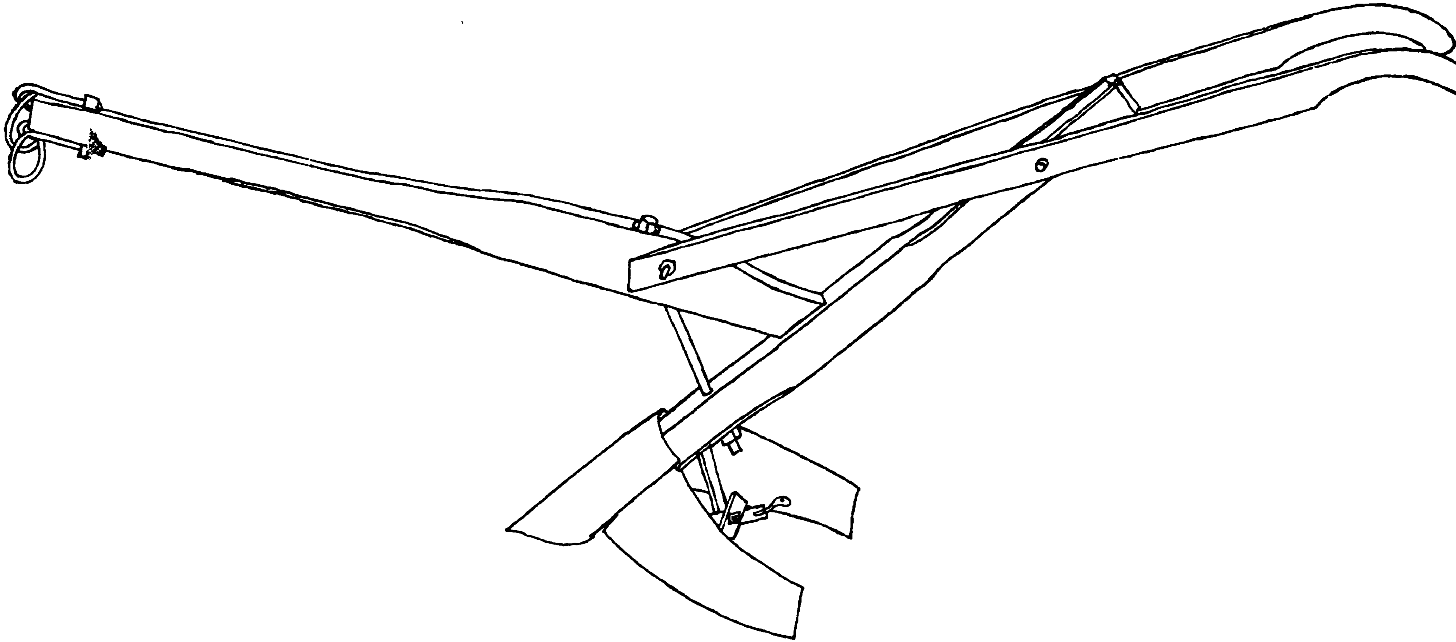


FIG. 2.- THE CROSS FURROW-BASIN SYSTEM OF CULTIVATION AND IRRIGATION.



Block by Survey Dept. Ceylon.

FIG. 3.—HOME-MADE RIDGING PLOUGH.

plenty of loose soil with which to throw up ridges and furrows. After drawing the furrows, water-distributing ditches may be drawn at convenient intervals across the field, and lastly the inlets and outlets for conducting the flow of water to and from the furrows should be made by hand labour. The spacing of furrows has to be determined for each particular orchard ; but in general it may be said that the furrows should be so spaced according to the physical texture of the soil that, when vertical penetration of water has ceased, there remains no dry soil between them. The number of furrows will depend upon the soil space occupied by the lateral root spread. As the trees grow and the roots expand, more furrows are added. In the rainy season no cultivation is to be done but the entire space may be sown with a leguminous cover, such as *Crotolaria juncea* or *Phaseolus mungo,* which completely covers the ground with a carpet of luxuriant green verdure and effectively smothers weeds. This cover crop is uprooted after six weeks towards the end of the monsoon and left on the field to rot as green manure and then lightly disced into the soil. At the end of the monsoon, the furrows are drawn once more and dry weather operations of cultivation and irrigation are begun. In the cross furrow-basin method of irrigation, water is impounded for a few minutes exactly as in the basin system and therefore it is not able to penetrate into the soil in all directions as is the case in the Californian system in which the downward and lateral capillary movement of water is kept up in action by water flowing in the furrows continuously for a number of hours. Also the depth of penetration of water in the cross furrow-basins will depend upon the quantity of water collected in the basins and the furrows and the spread of water into the soil will be mostly vertically downwards. There will be, in fact, very little lateral wetting of the soil beyond the bunds.

The main advantage claimed for the cross furrow-basin system over the local basin system is that it allows of wetting and economical management of soil occupied by roots beyond the drip of the tree. However, the fact should not be lost sight of that the chief factor in deciding the adoption of an irrigation system is the supply of water available for irrigation.

In the cross furrow-basin system the quantity of water consumed is almost twice the quantity required in the local basin system because in the former a larger root spread is wetted. If the quantity of water sufficient to irrigate the whole root-spread is not available, or is too expensive, the choice is to be made between the basin and the cross furrows, that is, the tree has to be irrigated either in the basin underneath the tree crown or in the cross furrows beyond the drip. Which of these two ways will be more advantageous from the point of view of tree

requirements has to be next considered. Study of the root-spread of citrus trees under the conditions of a dry climate, clean cultivation, green manuring and no permanent cover cropping shows that nearly half the root-spread lies beyond the drip. If we were to divide the root spread in two zones one within the drip and the other beyond the drip, it will be seen from Plate 2, page 6, *The Tropical Agriculturist*, Vol. XCII., No. 1, January, 1939, that the root zone beyond the drip is more branched and therefore capable of carrying a larger number of the fibrous feeding organs than the zone within the drip. It is logical, therefore, that, if it is a question of choosing between the two, the beyond-the-drip zone should be preferred for applying water. While making the cross furrows it should be particularly borne in mind that the furrows nearest the tree should be twice as broad as any other furrow in order that it may hold a good quantity of water and that half its width should be situated almost within the drip.

When the trees are being weaned from the basin in favour of the furrows for the first time, the change should be effected gradually. In the first season the trees may be irrigated and manured both ways, in the basins as well as in the furrows. By this arrangement the trees will have a chance to build up well in advance a sufficient quantity of fibrous feeding organs on that part of the root system beyond the drip so that from the following year the beyond-the-drip roots can be entirely depended upon to take over the functions of the basin-fed roots.

The writer was able to obtain very satisfactory crops of grapefruit (spaced 25 feet) at the Ganeshkhind Fruit Experiment Station in India by irrigating and manuring the trees beyond the drip, except during the excessively hot weather in April (maximum temperature of the day ranging from 102 to 106°F.) when water was provided on three occasions in the basins within the drip in addition to that provided in the furrows beyond the drip. This extra flooding in the basins is necessitated only for hot and severe weather conditions when fruit-drop is feared owing to excessive transpiration and lack of proper humidity in the orchard.

It will be seen from the above description that the cross furrow-basin method under Indian conditions allows of the wetting of the soil underneath the crown as an emergency measure whereas during the dry but cool weather it advantageously admits of irrigation beyond the drip of the tree crown. Besides, for cultivating the soil, the furrows beyond the drip can be destroyed and remade at any time cheaply by means of bullock-drawn implements. The repeated cultivation of the soil after every two irrigations beyond the drip by the blade harrow distinctly lessens the intensity of weed infestation and helps to

keep the roots feeding below the cultivated portion which efficiently absorbs the irrigation water. The superiority of this method in preserving physical texture of the soil as compared to the flooding in basins which destroys the porosity of the wetted soil is obvious.

Making of furrows by bullock-drawn implements when the tree crowns widen will be difficult unless the spacing is so wide as to leave an open space of 8 feet between two adjacent trees at the age when they are expected to reach their maximum spread. Though the performance of widely-spaced trees is decidedly superior to closely-spaced ones in the more advanced age of the plantation, wider spacing does raise an important issue in the economy of a young plantation as it amounts to reducing the number of trees per unit area. In fact, there is no particular advantage in wider spacing in regard to the individual yield of young trees so long as their roots and branches do not compete for space with the adjoining trees. A unit area of a closely-spaced orchard would contain a greater number of trees and would consequently give a greater yield, so long as trees are young and enough space is left between the trees for admission of sunshine, than an equal area having fewer trees of the same age but which are widely spaced. This drawback of wide spacing in a young orchard irrigated by the cross furrow-basin system can be largely compensated by growing for a few years an intercrop of short-lived plants such as vegetables on the soil unoccupied by roots of the tree, thus bringing an additional return. It should be borne in mind, however, that an additional supply of water and manure will be needed to grow the catch crop. In conclusion it may be stated that the real test of the economic usefulness of any method of irrigation can only be judged from the progressive cropping and outturn of a plantation over a period of years. No method, however efficient in wetting the soil, can be adopted unless it brings adequate monetary returns as a result of progressive performance of trees.

ACKNOWLEDGMENT

The writer is indebted to Mr. Sitaram K. Chaudhary, a former student at the Ganeshkhind Fruit Experiment Station, Poona, India, for preparing the diagrams of the systems of irrigation.

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DEPARTMENTAL NOTES

COCONUT OIL

IT was stated in the last paragraph of *Coconut Oil—Properties and Composition* published by the Coconut Research Scheme of Ceylon, Bandirippuwa Estate, Lunuwila, that coconut oil developed a type of rancidity known as " Ketone rancidity " under the action of moulds especially when the oil is not free from moisture.

The observance of the following instructions in the preparation, transport and storage of coconut oil will ensure freedom from moulds and moisture :—

I. *Preparation of the Oil.*—

(i.) It is necessary to have good well-dried copra, *i.e.*, dried to 6 per cent. moisture, and free from moulds.

(ii.) The copra must be expressed and collected in clean equipment.

(iii.) It is most important to separate the foots (cake residue, &c.) from the crude oil as quickly as possible.

(iv.) When this is done by settling, the settling tanks should be frequently cleaned.

(v.) The oil must be free from moisture (British Standard Specification $<0{\cdot}25$ per cent.). When it is a question of refined oil, for example, which has been treated and subsequently washed, it must be filtered and/or heated to 110–120° C. to remove last traces of moisture. This latter also effects sterilization.

II. *Storage and Transport.*—

(i.) The oil must be stored as far as possible away from the action of light and air.

(ii.) Small quantities of refined oil, for example, could be stored satisfactorily in soldered kerosene tins. Large quantities in drums.

(iii.) To exclude the action of air, vessels are best kept as full as possible.

III. *General.*—

(i.) In temperate climates, *i.e.*, at temperatures below 75° F., coconut oil is, of course, a solid. In this state it is much less susceptible to deterioration than in the liquid form as in the tropics.

WORK IN PROGRESS IN THE BOTANICAL DIVISION OF THE DEPARTMENT OF AGRICULTURE

(This report was read by the Botanist at the meeting of the Central Board of Agriculture held at Peradeniya on July 20, 1939, and is reproduced here for the information of all agriculturists. Ed.)

REPORT

I have been asked to give the Board an account of the work that is in progress in my division, so that members may know something of what we are doing to help the villager. In the short time available, I shall be able to mention only our major jobs, and I shall not be able to deal in detail even with them, but I shall be very pleased to give members any further information that we have, if they will ask me afterwards.

Ceylon exports some 400 tons of kapok every year, mostly to England, where it fetches 6*d.* a pound compared with $7\frac{1}{2}$–8*d.* paid for kapok from Java. The chief defects of the Ceylon product are that it is of a bad colour, that it is dirty and that it does not have the buoyancy of kapok from Java, and we were asked to say to what these defects were due. We examined samples of Ceylon kapok shipped from Colombo, samples taken from local trees and from trees raised from Java seed, and it appeared to us that there were no essential differences between them—in fact, when we treated them in the same way, we could not distinguish between them—and we came to the conclusion that the major differences between the Ceylon and Java products when they appear on the London market were due to the way that they had been cleaned in Ceylon or Java. Towards the end of last year, I was able to visit Java and to see something of the kapok industry there, and I am now strongly of the opinion that the defects in the quality of our kapok can be remedied by a more efficient cleaning of the seed cotton. I have got permission to set up an experimental machine that will clean kapok by the method that is used in Java, and it is proposed to send trial consignments to England for report. Should my opinion be confirmed in London, there will be an opening for good-quality kapok from Ceylon.

For nearly two years, we have been experimenting with the soybean. The plant has been the most important food-crop in China for thousands of years, and during the present century it has become more increasingly grown in other countries. It has an amazing variety of uses : the green plant can be used as green manure, or fodder, or for silage ; the young pods are eaten

as a vegetable ; the fresh seeds are sprouted and cooked as young shoots ; the dried seeds are eaten in soup, in curry, are pounded into flour, are transformed into milk, or cheese, or curds, or *roti* ; or roasted and ground to produce a substitute for coffee. They are crushed to give a valuable oil and the resulting cake is fed to stock or used as fertilizer. The oil is used as food and in the paint and soap trades. The great advantage of this bean over similar food crops is that it contains very little starch, and has all its reserve food stored as protein and oil. It can therefore take the place of meat in a diet, and it is particularly valuable to diabetics.

The obvious question arises—why have we not made more use of the crop before ? It appears to have been tried at intervals, but not appreciated and not encouraged. It is said to require inoculation with a particular bacterium before it can be grown successfully—we agree that better results are obtained if the bacterium is present, but we are not satisfied that its presence is essential, at least on average or good soils. We have made trials with a large number of varieties under a wide range of conditions, and our work is not yet completed, but we are now in a position to make general recommendations on which varieties to grow and how to grow them. Some seed is available now for trial and we are about to publish both a leaflet and an article in *The Tropical Agriculturist.*

About 3 years ago we started to investigate the possibility of producing castor oil for the Medical Department. As a result of a series of trials with local and imported varieties, we have selected a type which will give good yields under average conditions, and have determined what it costs to produce a pound of seed. Last year we sent a ton and a half of this seed to Colombo for an experimental extraction of oil, and from the results of that test we shall be able to determine whether the local production of castor oil is an economic proposition. In the meantime, we are continuing to experiment with methods of treatment that may perhaps increase the yield of seed per acre, and are maintaining 3 acres of castor for the supply of seed of the improved type.

We have recently started work on potatoes that may prove to be of great importance to Ceylon. It is well known that the European potato will grow in the Tropics only at high elevations, but it was realized only a few years ago that the potatoes brought by our forbears from South America to Europe form a very small fraction of the kinds of potato growing in the native haunts of the genus. Species of Solanum are found in South America at elevations from sea level to 12,000 feet, and under conditions of rainfall varying from 10 to 100 inches per annum, and there is no reason to think that species could not be found

that would grow successfully under tropical conditions. A series of expeditions has collected planting material which is now being distributed, and we have received from England tubers of 100 different varieties. It is quite possible that 90 of them will dislike living in Ceylom ; of those that survive, years of improvement will be necessary before we can hope to produce tubers of the quality of those imported from Europe ; but even if only one survives, we shall at least have a starting point from which to look forward to the time when every householder will be able to grow his own potatoes, no matter where he may live.

My friend Dr. Joachim has in recent years made numerous trials on the canning and bottling of fruits grown in Ceylon and has achieved considerable success, but he has failed so far to produce a good canned pineapple ; although we can grow quite good fruits for dessert, they are too fibrous to be used for canning. About $2\frac{1}{2}$ years ago, we imported 4 new varieties, 3 from Queensland and 1 from Malaya, and established them in different parts of the Island. We had great difficulty in persuading them to live here—in fact, one of them has decided quite definitely that it does not like Ceylon conditions—but we have persevered, and at the beginning of this year we were presented with the first fruits of our enterprise. They have been tried by the Chemist, who has pronounced them excellent in flavour, in texture and in juiciness, so that we now have distinct hopes of a pineapple that can be sold either fresh or canned according to demand.

There is a small but regular cotton growing industry which supplies seed cotton to the Spinning and Weaving Mills in Colombo. Its main area of operation is the Hambantota district, but of recent years it has spread to the dry areas of the northern part of the Island, and last year it produced 355 bales. The variety grown is Cambodia which was introduced in 1922, on the advice of experts from India. Since that time, the quality of the fibre has deteriorated considerably, for cotton is a crop which must be selected every year if the quality is to be maintained, and no one has been available to do the selection. We have now imported fresh Cambodia from India and we are also trying two African varieties that have been evolved since 1922 and that have shown great promise. We have been multiplying these cottons for two years now, and in October we shall put down trials at Bata-ata in the Southern Province. If they are successful, we shall establish a small station at Tissamaharama for selection of seed and a multiplication station at Bata-ata and shall replace most of the cotton now being grown (all of it if we can !) with the new seed.

On the Experiment Station, Peradeniya, we have been growing a collection of 37 of the world's best sugarcane varieties. Later

in the year, or perhaps next year, we hope to transfer them to a new sugar station in the Eastern Province, where we can investigate the possibilities of growing sugar on a large scale.

Although most of our work is intended for the benefit of the villager, yet some of our schemes have a wider interest; the cultivation of Cinchona for example. You have already seen from the editorial in the June number of *The Tropical Agriculturist*, that we are contemplating trials with Cinchona, and I do not propose to discuss that subject now, but it is a crop in which estates may perhaps be interested.

Pyrethrum is another. Pyrethrum is a product that can be expected to interest only a small proportion of village cultivators because it grows only up-country, but it may interest estates. As you will know, pyrethrum is a very important insecticide and is prepared from the dried flower-heads of a species of *Chrysanthemum*. We were so fortunate as to get some good-quality seed a few years ago, and we have grown plants in Nuwara Eliya, at Hakgala, and at Boragasketiya just below Hakgala Gardens. We have had difficulty in acclimatizing them, and we have not yet completely succeeded in getting a strain that will stand up to heavy monsoon rains; but we have had some degree of success, and this year we were able to send to England a consignment of flower-heads for examination. The report is not startling but it is quite satisfactory, particularly so when we remember that the flower-heads were picked by people with no experience of the trade and that the crop is useless if the flowers are picked at the wrong time. There is definitely a market in England for pyrethrum of this quality. Lest that remark should raise hopes of a new fortune-making discovery, I had better tell you what the market position is. Up to a few years ago, the Japanese had a monopoly in the pyrethrum trade. A few years ago, it was discovered that pyrethrum could be grown very successfully in the highlands of Kenya, at elevations over 8,000 feet, and that the resulting product was richer in insecticide than the Japanese one, over which it now commands a premium of about 45 per cent. The Kenya output is at present small, but it is increasing.

Kenya flowers have a guaranteed pyrethrin content of 1·3 per cent. Japanese flowers vary from 0·8–1·1 per cent. The sample sent to London contained 1·04 per cent., so that it is equal to high grade Japanese material and may be capable of improvement by selection. Whether that selection is worth while would be determined only by the importance that a pyrethrum trade promised to become. My own opinion is that it can never be more than a small trade because of the limited conditions under which we can grow the plant; nevertheless, it may be a profitable sideline.

CULTIVATION OF PADDY

WITH reference to the very divergent views often expressed regarding the average yield of paddy per acre per annum in this country, the cultivation sheets of the *yala* season 1938 and of the *maha* season 1938–39 at the Experiment Station, Anuradhapura, are reproduced for general information. It is necessary to state that the 25 acres brought under the crop in the *yala* season formed part of the 36 acres which were cultivated in the *maha* season. Therefore, taking 36 acres as the size of the farm, and the total yield of the farm in the two seasons as the average, annual yield per acre is a trifle over 70 bushels, and the average cost of production is about Re. 1·37 a bushel, with no allowance for the rent of the land. From these figures it would appear that if the price of paddy is stabilized at about Rs. 2·25, and the water supply is reasonably assured, paddy cultivation is not altogether beneath the notice of the capitalist.

A similar statement relating to the Paddy Station at Paranthan will be published in the next issue of *The Tropical Agriculturist.*

Division : Northern.
Name of Station : Experiment Station, Anuradhapura.
Acreage under Paddy : 36 acres.
Season : Maha 1938/39.
Variety of Paddy : Vellai Illankalayan (28061).

I.—LABOUR.—

Operation	Men at 60 cts.	Women at 30 cts.	Boys at 45 cts.	Total. Rs. c.	Cost per Acre Rs. c.
1. Nurseries for transplanting	20½	2	—	12 90	0 36
2. Ploughing and mudding	174	—	27	116 55	3 24
3. Work on bunds and channels	61½	148½	14	87 75	2 44
4. Mammotying of unploughable areas	31	—	36½	35 2	0 97
5. Harrowing	95	—	—	57 0	1 58
6. Levelling	140	—	20	93 0	2 58
7. Applying manures	10¼	—	—	6 15	0 17
8. Cutting, transporting and applying green manures	—	—	—	—	—
9. Sowing or transplanting	22¼	245	—	86 85	2 41
10. Weeding, thinning out and filling vacancies	25	300	—	105 0	2 92

Operation	Men at 60 cts.	Women at 30 cts.	Boys at 45 cts.	Total Rs. c.	Cost per Acre Rs. c.
11. Irrigating and watching ..	333 ..	— ..	— ..	199 80..	5 55
12. Scaring birds and monkeys	— ..	85 ..	— ..	25 50..	0 71
13. Harvesting ..	136½..	62 ..	— ..	100 50..	2 79
14. Transporting and stacking	144 ..	69 ..	10 ..	111 60..	3 10
15. Threshing and winnowing	163½..	82½..	32 ..	137 25..	3 81
16. Drying, measuring, and transporting to store ..	70½..	— ..	— ..	42 30..	1 18
17. Pest and disease work ..	— ..	— ..	— ..	— ..	—
18. Contribution to Communal works ..	— ..	— ..	— ..	— ..	—
19. Fencing including repairs	— ..	— ..	— ..	— ..	—
II.—SEED 73½ bushel at Re. 1 ·40 per bushel				..102 90..	2 86
III.—MANURES.—					
Artificial manure: 42 cwt. 40 lb. of Nicifos at Rs. 11 ·20 per cwt. including transport charges				..474 40..	13 18
IV.—DEPRECIATION ON IMPLEMENTS—vide Statement A				.. 55 1..	1 53
V.—COST OF ANIMAL LABOUR.—vide statement B				..143 54..	3 99
VI.—OVERHEAD CHARGES.—					
Salary of Conductor for five months at Rs. 40 ·83 per mensem				..204 15..	5 67
VII.—MISCELLANEOUS.—					
Cost of string 18½ lb. *theda* rope and 2½ lb. C string at 12 cts a lb.				.. 2 52..	0 7
Cost of kerosene 17¾ bottles at 15cts. a bottle				.. 2 66..	0 7
All other unspecified items ..				.. — ..	—
TOTAL COST OF PRODUCTION				2,202 35	61 18

	Maha 1938–39 Bus. Meas.	Maha 1937–38 Bus. Meas.
Total yield	1,584 23½ ..	1,984 20¾
Yield per acre	44 1 ..	46 29
Cost of cultivation per acre ..	Rs. 61 ·18 ..	Rs. 53 ·51
Cost of production of 1 bushel of paddy	Re. 1 ·39 ..	Re. 1 ·14

Straw

Yield of straw : 35 tons 3 cwt. 14 lb. (*i.e.*, 26,250 bundles of 3 lb. each).
Value of straw : Rs. 393 ·75 (*i.e.*, Re. 1 ·50 per 100 bundles—local rate).
Value realized by sale of straw : Nil.

	Rs. c.	
Approximate value of straw used at the station	30 0	(for thatching threshing sheds)
	120 0	(for feeding cattle)
Approximate value of straw reserved for Polonnaruwa	..243 75	
Total	..393 75	

Remarks

A. Cost of Production has increased because of the following reasons :—

(1) Increase in the Conductor's salary—normal increment due to him.

(2) Average rate of wages of men works out now to 60 cts. per man per diem as indigenous labourers do not work for any wage under 60 cts. Previously initial wage was 50 cts. per diem.

(3) Owing to inclusion of the cost of cultivating three acres under an Optimum Duty of water for Paddy Trial.

(4) Drop in the average yield from 46 bushels 29 measures to 44 bushels 1 measure per acre.

B. Reason for drop in yield :—

Insufficiency of irrigation water, specially for 10 acres (Block C I). In this 10 acres the yield dropped from 46 bushels per acre for *maha* 1937–38 to 28 bushels per acre for *maha* 1938–39. This poor yield brought down the average yield from the 36 acres.

STATEMENT A

Depreciation on Implements

Implements	A No. in use	B Cost Price each Rs. c.	C Length of working life : years	D Total Depreciation. A×B / C Rs. c.	E No. of working days per annum	F No. of days worked for *maha* 1938–39 paddy season	G Cost for *maha* 1938–39 season D×F / E Rs. c.	H Cost of replacement of parts and costs of repairs during season Rs. c.	Nett depreciation Rs. c.
1. Ploughs—									
Type *a* " Ceres "	3	35 0	10	10 50	160	39	2 56	5 0	7 56
b									
c									
2. Burmese harrows	3	3 50	3	3 50	50	30	2 10	0 60	2 70
3. Yokes—									
a ordinary ..	3	1 50	3	1 50	60	35	0 87	..	0 87
b improved ..	3	3 50	10	1 5	140	39	0 29	—	0 29
4. Levelling boards									
a large ..	2	2 0	5	0 80	30	20	0 53	—	0 53
b hand ..	4	0 75	3	1 0	40	20	0 50	..	0 50
5. Mammoties ..	10	1 10	7	1 57	70	42	0 94	—	0 94
6. Harvesting knives	12	0 60	4	1 80	40	20	0 90	1 20	2 10
7. Threshing mats .	1	25 0	3	8 33	75	37	4 11	7 10	11 21
8. Winnowing machine ..	1	200 0	15	13 33	75	30	5 33	—	5 33
9. Gunny bags ..	800	12½	3	33 33	365	180	16 44	6 30	22 74
10. Hurricane lamps	2	2 90	12	0 48	40	20	0 24	—	0 24
Total ..									55 1

STATEMENT B

Cost of Animal Labour

1.—Bulls

Description	A No.	B Cost of each Rs. c.	C Estimated length of life. Years	D Depreciation per annum $\frac{A \times B}{C}$ Rs. c.	E Food cost per annum Rs. c.	F Cost of cattle keepers per annum Rs. c.	G Total cost per annum D+E+F Rs. c.	H No. of working days per annum	I No. of working days for *maha* 1938–39 season	J Nett cost for *maha* 1938–39 season $\frac{G \times I}{H}$ Rs. c.
(*a*) Kangayam bulls Nos. 13 and 14 ..	2	100 0	8	25 0	82 25	36 50				
(*b*) Ditto Nos. 15 and 16 ..	2	80 0	8	20 0	82 25	36 50	423 75	210	30	60 53
(*c*) Ditto Nos. 18 and 19 ..	2	90 0	8	22 50	82 25	36 50				
(*d*) ..										
Total ..										60 53

2.—Buffaloes

Description	A	B	C	D	E	F	G	H	I	J
(*a*) Buffaloes, Single ..	6	25 0	8	18 75	—	147 27	166 02	Per two seasons	Per one season	83 1
(*b*)										
(*c*)										
(*d*)										
Total ..										83 1

Total cost of bulls and buffaloes for *maha* 1938–39 season Rs. 143·54

Division : Northern.
Name of Station : Experiment Station, Anuradhapura.
Acreage under Paddy : 25 acres.
Season : Yala—1938.
Variety of Paddy : *Pachai Perumal* (2462/11).

I.—LABOUR.—

Operation.	Men at 50 cts.	Women at 30 cts.	Boys at 45 cts.	Total. Rs. c.	Cost per Acre. Rs. c.
1. Nurseries for transplanting	—	—	—	—	—
2. Ploughing and mudding	173	—	—	86 50	3 46
3. Work on bunds and channels ..	66	100½	—	63 15	2 52
4. Mammotying of unploughable areas ..	—	—	—	—	—
5. Harrowing ..	52	—	—	26 0	1 4

Operation	Men at 50 cts.	Women at 30 cts.	Boys at 45 cts.	Total Rs. c.	Cost per Acre. Rs. c.
6. Levelling	76	—	—	38 0	1 52
7. Applying manures	6½	—	—	3 25	0 13
8. Cutting, transporting and applying green manures	—	—	—	—	—
9. Sowing	6½	—	—	3 25	0 13
10. Weeding and filling vacancies	9	58	—	21 90	0 88
11. Irrigating and watching	239	—	—	119 50	4 78
12. Scaring birds and monkeys	—	66½	—	19 95	0 80
13. Harvesting	75½	44	—	50 95	2 4
14. Transporting and stacking	88½	63	19	71 70	2 87
15. Threshing and winnowing	97	61	—	66 80	2 67
16. Drying, measuring, and transporting to store	39	—	—	19 50	0 78
17. Pest and disease work	4	—	—	2 0	0 8
18. Contribution to Communal works	—	—	—	—	—
19. Fencing including repairs	—	—	—	—	—
II.—SEED 52½ bushels at Re. 1 ·40 per bushel				73 50	2 94
III.—MANURES.—					
Artificial manures 25 cwt. of Nicifos at Rs. 11 ·20 per cwt.				(*a*) 280 0	11 20
IV.—DEPRECIATION ON IMPLEMENTS vide Statement D				36 29	1 45
V.—COST OF ANIMAL LABOUR vide Statement E				125 36	5 1
VI.—OVERHEAD CHARGES.—					
Salary of Conductor for 4 months at Rs. 39 ·16 per mensem				156 64	6 27
VII.—MISCELLANEOUS.—					
Cost of string 20½ lb. at 12 cts. per lb.				2 46	0 10
Cost of kerosene 10¼ bottles at 15 cts. a bottle				1 54	0 6
All other unspecified items				—	—
TOTAL COST OF PRODUCTION				1,268 24	50 73

	Yala—1938 Bus. Meas.	Yala—1937 Bus. Meas.
Total yield	950 27	733 22
Yield per acre	38 1	36 22

	Yala 1938.
Cost of cultivation per acre	Rs. 50 ·73
Cost of production of 1 bushel of paddy	Rs. 1 ·33

Straw

Yield of straw : 20 tons 1 cwt. 88 lb. (15,000 bundles of 3 lb. each).
Value of Straw : Rs. 150 (Re. 1 per 100 bundles—local rate).
Value realized by sale of straw : Nil.

	Rs. c.	
Value of straw used at the station	30 0	(for thatching threshing sheds)
	120 0	(for feeding cattle)

Remarks

(*a*) Cost of 25 cwt. Nicifos calculated including transporting charges.

STATEMENT D

Depreciation on Implements

Implements	A No. in use	B Cost Price each Rs. c.	C Length of working life : years	D Total Depreciation $\frac{A \times B}{C}$ Rs. c.	E No. of working days per annum	F No. of days worked for Yala paddy season	G Cost for Yala Season $\frac{D \times F}{E}$ Rs. c.	H Cost of replacement of parts and costs of repairs during season Rs. c.	Nett depreciation Rs. c.
1. Ploughs—									
Type *a* " Ceres "	3	35 0	10	10 50	160	22	1 44	2 50	3 94
b									
c									
2. Burmese harrows	3	3 50	3	3 50	60	18	1 5	1 50	2 55
3. Yokes—									
a ordinary ..	3	1 50	3	1 50	70	30	0 64	—	0 64
b improved ..	3	3 50	10	1 5	140	22	0 16	—	0 16
4. Levelling boards									
a large ..	2	2 0	5	0 80	30	12	0 32	—	0 32
b hand ..	5	0 60	3	1 0	30	13	0 43	-	0 43
5. Mammoties ..	10	1 10	7	1 57	70	25	0 56	—	0 56
6. Harvesting knives ..	12	0 60	4	1 80	40	12	0 54	1 80	2 34
7. Threshing mats .	1	25 0	3	8 33	75	20	2 22	6 30	8 52
8. Winnowing machine ..	1	200 0	15	13 33	78	18	3 7	—	3 7
9. Gunny bags ..	476	0 12½	3	19 83	365	180	9 77	3 80	13 57
10. Hurricane lamps	2	2 90	12	0 48	50	20	0 19	—	0 19
								Total	36 29

STATEMENT E

Cost of Animal Labour

1.—Bulls

Description	A No.	B Cost of each Rs. c.	C Estimated length of life. Years	D Depreciation per annum $\frac{A \times B}{C}$ Rs. c.	E Food cost per annum Rs. c.	F Cost of cattle keepers per annum Rs. c.	G Total cost per annum. D + E + F Rs. c.	H No. of working days per annum	I No. of working days for Yale season	J Nett cost for Yala season $\frac{G \times I}{H}$ Rs. c.
(*a*) Jaffna pair	2	90 0	8	22 50						
(*b*) Kangayam pair No. 1 ..	2	90 0	8	22 50	246 77	90 0	404 27	210	22	42 35
(*c*) Ditto No. 2	2	90 0	8	22 50						
(*d*)										
Total ..									.	42 35

STATEMENT E—*contd.*

Cost of Animal Labour

2.—Buffaloes.

Description	A No.	B Cost of each Rs. c.	C Estimated length of life. Years	D Depreciation per annum $\frac{A \times B}{C}$ Rs. c.	E Food cost per annum Rs. c.	F Cost of cattle keepers per annum Rs. c.	G Total cost per annum D + E + F Rs. c.	H No. of working days per annum	I No. of working days for Yala season	J Nett cost for Yala season $\frac{G \times I}{H}$ Rs. c.
(*a*) Light brown pair ..	2	25 0	8	6 25	Nil	147 27	166 2	Per 2 seasons	Half the total cost per annum	83 1
(*b*) Brown pair—straight horns	2	25 0	8	6 25						
(*c*) Ditto—stout horns ..	2	25 0	8	6 25						
(*d*)										
Total ..										83 1

Total cost of bulls and buffaloes for *yala* season Rs. 125·36.

SEASONAL PLANTING NOTES

CALENDAR OF WORK FOR AUGUST AND SEPTEMBER

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IN these notes one cannot long avoid reference to weather conditions since these are the main guide in designing working operations in the garden.

August generally experiences a tailing off of the monsoon rains in south-west regions of the Island, temperature becoming very equable in the process; the surface soil in beds and borders becomes very friable and workable and one begins to feel that these are indeed the conditions under which real gardening can be undertaken.

The influence of altitude has to be noted, however, as around elevations of 5,000 to 6,000 feet, and over, strong winds still prevail though these tail off towards the end of the month.

In the north and east and dry zone proper which are not benefited by the south-west there has already commenced a season of long drought, rarely broken before October and till such times little in the way of gardening proper can be undertaken unless copious supplies of water are available.

In the areas with a south-west rainfall, seasonal operations in the month of August are many. It is a very good time for pruning of trees and shrubs and for thinning out the dead or over-crowded branches of fruit trees. This pruning is rarely properly understood in the East since the orthodox principles do not meet requirements of plants that are perpetually in growth and have no proper rest period.

Nevertheless, the cutting back of many of the garden shrubs is more a necessity here than in temperate conditions, for, if this is not done, growth becomes wild and the quality of flower and fruit deteriorates. Now is a very good time to tackle the problem, and particularly as regards the ornamental shrubs such as acalypha, shoeflower, panax, arundo, clerodendron, brunfelsia, lantana (horticultural varieties), but not bougainvillaeas. The normal flowering tree does not often need pruning but occasionally branches become too lanky or overhang

too much and these should be cut back cleanly and the cut surface tarred over. A certain type of flowering tree such as *Cassia multijuga* and *Randia maculata* need to be pruned back hard every second year since it is on the newly made growth that all flowers are produced. To allow these to grow, the natural way of other flowering trees, leads to a paucity of flower and an over-abundance of growth.

In brief, the principles of pruning might be summarized as follows :—

(1) For fruit trees, thin out branches so as to allow free access of light and air ; remove all dead wood, snags, superfluous suckers and roots.
(2) Always use a sharp knife or saw, and cut in such a way as to ensure quick healing.
(3) When cutting back lateral branches, always cut at a fork.
(4) In removing a large branch, saw it off roughly at about a foot from the trunk, and finally saw off and plane the surface of the stump that remains (cut the underside first).
(5) Treat all wound-surfaces with coal tar preventing thereby the entry of moisture or parasitic fungi.
(6) Cut in a slanting or upright direction so that when completed and treated rain is thrown off naturally.
(7) In general, pruning should be performed when growth is least active, but it should not be done during a drought period.

It is stated above that bougainvillaeas should not be pruned and there is a very good reason for this. Normally the gardener plants this shrub and allows it to grow at will. The sequence is a succession of long tall shoots resulting in bare stems for 4 or 5 feet from the ground and long drooping shoots with clusters of flowers at the terminals only. The correct procedure is, after planting, to fix 3 or 4 stout stakes or irons in the form of a triangle or square around the plant and as the plant sends out its long branches bend these in a downward or horizontal direction and tie securely to the stakes or irons. A bush is then formed with foliage down to the ground, and as the plant grows and sends out further shoots these too must be pulled down and tied in. In effect the result is that the sun beats down on the bush, ripening the whole shoot, and flowers appear laterally all along the shoot intsead of merely at the tip or the terminal flower which results from a bush left to form itself normally.

Many requests for information in this respect and on the best position for bougainvillaea (and shoeflower shrubs) are received and it may here be mentioned that bougainvillaea must have a well-drained site, an open position, and some form

of root restriction if these are to be grown successfully under our humid conditions. Its natural home is the dry and sunny parts of South America, yet we possess most of the best varieties and with proper treatment grow them to perfection.

Most of the varieties strike root from cuttings, the varieties "Rosa Catalina" and "Laterita" being the exceptions, provided they are given ample sand in the propagating beds. When rooted it is best to grow them on in some form of tub or tin—at Peradeniya tar barrels cut into two and cleansed are very satisfactory—with plenty of old bricks for drainage and a good but light soil in which to grow. They remain in these until the first flowers are produced after which they are given selected sites on either mounds or well-drained positions in the full exposure to all the sun possible. They are not taken out of the tin or tar barrel but planted intact and, to further assist good drainage, holes are made in the barrel by driving an *alavango* through the sides here and there.

Orchid potting can now be undertaken, though this in fact applies to the greater part of the year, except only in the hot and dry months, according to the species grown. The time to pot is usually after flowering and before new growth commences, and that is when the plant is in its most dormant stage. A good serviceable mixture for epiphytes consists of broken crocks (flower pots or tiles), sphagnum moss, charcoal, old fern or bracken roots, well-leached coir fibre or coconut husks, and old bark of trees. The mixture should be clean, well chopped and mixed, and used sparingly. Do not overpot, that is, keep to a small-sized pot as long as possible and see there is ample drainage. The plant potted should more or less sit on the compost rather than be buried in it. For terrestrial or ground orchids some loam or well-decomposed cattle manure should be included together with a portion of steamed bones and in this type of orchid the plant can be potted deeper in the soil than with epiphytes.

All preparations should this month be made in up-country gardens for sowing seed of annuals and biennials required for a good show next year, the sowings being made next month. Cuttings of begonias, abutilon, iresine, santolina, perewinkle, berberis, cineraria, anthericums, and such like can be put into beds or boxes for planting out at the end of the year into beds and borders.

Among the vegetables, artichokes should be coming along and planting out from boxes or sowing direct of quick crops such as peas, beans, spinach, beet, cabbage, carrot, knol-kohl, lettuce and the like can be made to ensure crops before the worst of the north-east monsoon sets in.

There is little scope in the dry regions at this time of the year beyond reaping in dry-grain crops. The mango crops have come to an end and the palmyra fruit season begins. Cultivated lands will now be prepared for onions, betel, kurakkan and the like.

Budding and grafting in the low moist zones are very satisfactory operations under August climatic conditions and, where rootstocks are available and are of sufficient age, this work should proceed. The rootstocks for grapefruit, orange, and mandarin are undoubtedly rough lemon and the sour orange. Mangoes too bud well since the sap is well on the move and most varieties, especially the *wal-amba,* are useful as rootstocks. The wild mango, *etamba,* is of very slow growth in its young stage and is best budded *in situ,* and for these reasons it is not generally recommended at this stage. Budding methods are the inverted tee for citrus and rectangular patch for mangoes. Buds from only the very best and highest quality fruit trees should be used.

Normally the fruit-grower prefers to purchase the ready made plant, but raising one's own requirements should be given attention to on economic grounds. The sources of supply of seeds are gradually expanding and the Horticultural Division of the Department of Agriculture is always ready to advise as to sources of supply should difficulty arise.

September is generally a busy month though not to the extent of the previous month. Dry weather persists in the low country dry zones and in the moist zones a dry spell is usually experienced also. Watering of the new plantings put out during June–July may be needed and mulches of grass cuttings and the like should be applied to beds and borders and to trees or shrubs planted individually.

The gardens in the low moist zones should now be giving a deal of colour and one might now give some consideration to improvement in arrangement and colour in the flower borders for next season. It is generally noted that reds and yellows predominate with a paucity of blue flowers. Where this is so a note should be made to introduce small groups of such blue colour annuals and perennials that are fairly easily grown, for instance the blue plumbago, anchusa, exacum, salvia (several species but notably *Salvia farinacea* with *Salvia patens* up country) angelonia, the small blue China aster, browallia, torenia and the blue-mauve forms of petunia.

For the more permanent features of the border or shrubbery there is a large variety of flowering shrubs available which vary between 3 and 6 feet in height. A good selection covering a wide range of colour both in flower and foliage would include

uroskinnera, mussanda, rondeletia, calliandra, achanea, brunfelsia, clerodendron, acalypha, (*Acalypha torta* and other bright colour leaf varieties) graphtophyllum, hibiscus, kopsia, and for the taller shrubs for background randia, caesalpinia, *Lagerstroemia indica*, holmskioldia and hamelia. Bougainvillaeas are best grown in isolation rather than in mixed beds or borders. For drier areas a good selection of shrubs would include oleander, caesalpinia, pandanus, achanea, *Clerodendron inerme*, sophora, punica, *Lagerstroemia indica*, the beautiful *Tabernaemontana coronaria* of both single and double forms, and the common but not to be despised croton or codiaenum.

Towards the end of the month preparations can be made for the north-east planting season which season covers the whole Island and is in general the main planting season of the year.

A list giving a brief description of the main garden requirements of such bed and border plants is available free on application to Peradeniya and advantage should be taken of the fact.

Where plantings of flowering and shade trees or of fruit trees are anticipated, the holes should be excavated as soon as possible to allow the soil to settle well before actual planting takes place and if possible a month should elapse between refilling the holes and planting. With fruit plants this is very essential for generally if plantings are made in newly-filled holes the plant sinks as the soil settles resulting in too deep planting and subsequent water-logging. If it is realized that natural sinkage, even in a hard-rammed bed, amounts to 1½ inches for every foot depth excavation, it will be appreciated that a loosely-filled 2½ feet hole can well sink 9 to 10 inches below original level at time of filling.

Up-country, the month is a busy one as it is now that the majority of the season's (February–May) annuals must be sown, and pricked out. Sowings are generally made in boxes, pans or in covered beds in positions facing the east, and whether pots, boxes, or sheds are used, the soil for sowing in must be fine, light and rich. A sprinkling of sand should be added to render it porous and well-decayed cattle manure should be rubbed fine before mixing with the soil. Sow small quantities at intervals rather than all at once, keeping the balance seed in air-tight tins or bottles. Such plants as verbenas and petunias which are normally raised from cuttings should be put in during the month and be ready for November-December plantings. Dahlias which have now finished flowering should be cut down, allowed to remain in the soil for a fortnight, then lifted and stored in a dry shed for replanting in November-December next.

SELECTED ARTICLES

SOIL CONSERVATION IN THE TROPICS

(The following article, reprinted from the *Agricultural Periodical* (Monthly) of the Netherlands Society for Scientific Agriculture, 51st Volume, June, 1939, is a copy of a short paper read by Sir Frank Stockdale, K.C.M.G., C.B.E., Agricultural Adviser to the Secretary of State for the Colonies, at the request of the organizers of the Conference on Tropical Agriculture which was held at Wageningen, Holland, in December, 1938. Ed.).

AS far as the British Colonial Empire is concerned, it is just sixty-five years ago since attention was directed to the question of soil erosion. It was in 1873 that Sir Joseph Hooker, then Director of the Royal Botanic Gardens, Kew, drew the attention of the Secretary of State for the Colonies to the serious losses of soil which were taking place in Ceylon as the result of the opening for cultivation of the forest-clad highlands of that colony. As the result of this action, legislation was some years later enacted prohibiting the alienation of Crown lands, except in small areas for very special circumstances, at all elevations in excess of 5,000 feet. Similar enactments were passed from the year 1912 onwards in the mountainous islands of the West Indies for heights varying from 1,000 to 1,500 feet according to the particular island concerned.

This system of protecting the forest cover at the higher altitudes of island colonies constituted the first steps which were taken in the British Colonial Empire to deal with erosion. It is satisfactory in the hilly wet tropics only if measures are also taken to prohibit the opening of steep slopes and to protect the catchments and springs of the principal streams at lower altitudes. All lands opened for cultivation purposes must, however, be specially protected by anti-erosion measures if severe losses of top soil are to be prevented.

I personally began to take an active interest in soil conservation work in the tropics from 1920 when as Director of Agriculture in Ceylon it was apparent that much further protective work remained to be done on the tea and rubber estates in the hilly parts of that island if the enormous losses of soil from erosion were to be checked. The experiences of the Netherlands East Indies were freely drawn upon for control measures adopted and during my service in Ceylon I saw considerable advances made. Clean weeding practices were slowly, but gradually, abandoned, contour drains and silt pitting increased, low contour stone walls established, the general growing of cover crops begun and the contour platform system in the opening of new lands started. Many were sceptical at first, but progress was made by degrees as the result of experiment, education and propaganda. The results achieved up to 1930 were reviewed by a special Government Committee constituted to examine the

position. In the Report issued by this Committee in the following year there was expressed general commendation of the improvements which had been effected during the previous ten years but it was stressed that the position was still regarded as serious. Estate agriculture was considered to be mainly responsible for erosion in Ceylon and it was held that it was essential that the use of ground cover should be universally accepted, as it was only by the adoption of such a policy that erosion could satisfactorily be checked. In recent years, attention has been given also in the village lands and some useful demonstration areas started.

Since 1931 much attention has been focussed throughout the world on the problem of erosion and also on the measures which can be effectively employed to assist soil conservation. The position in the United States which was made clear to the world in the Report of the National Resources Board of 1934, and the action taken as the result of that report, has attracted universal attention. Those who were battling in the Colonies fifteen years ago to secure some recognition of the evils of and losses occasioned by erosion have seen the Governments of colonial dependencies inundated with demands for something to be done and with complaints that anti-erosion work is not proceeding sufficiently rapidly. There is no British tropical possession in which a review of the position has not been made and, where necessary, some measures undertaken to improve matters. Public opinion has been aroused, but not infrequently the staffs available for the work are insufficient and finance inadequate. It has been recognized, however, that considerable expenditure will have to be incurred and that the most satisfactory results will only be achieved when there is planned co-operation between administrative and technical staffs and the people themselves.

When questions of soil conservation are under consideration it is necessary to contemplate the issues involved in their broadest aspects. They must include not only the consideration of forest protection and anti-erosion measures but also those associated with the maintenance of soil structure and fertility. The reactions of vegetation on soil and possibly climate have their bearing on the general problem, as the whole concept of soil conservation covers the maintenance of its productivity. It is bound up with soil cover, the nature of the soil, the conservation of water supplies, the forestry position, the agricultural occupations of the people concerned and their social and tribal customs.

ACCELERATED EROSION

Accelerated erosion occurs in the form of sheet erosion, water erosion or wind erosion. It is brought about by an interference with the natural vegetal cover, by the omission of suitable anti-erosion measures and the lack of satisfactory methods of agricultural husbandry and of grassland and woodland management. The unthinking stripping of the soil's protective covering of vegetation is primarily responsible, but densities of population and developmental enterprises have required that large areas of hilly lands should be brought under agrarian production.

As far as the tropics are concerned, it is necessary to keep clearly in the forefront of any consideration of the subject the differences between the wet

and dry tropics. It is necessary, however, to recognize that the distribution of the rainfall is of greater importance, as far as erosion is concerned, than the actual total falls. Downpours of high intensity over comparatively short periods of duration invariably cause the maximum of " run-off " and erosion is always more serious in areas where long periods of dry weather are experienced than in those where a more even rainfall distribution prevails. In some areas of the wet tropics erosion is not nearly so severe as might be expected because of its more regular spread throughout the whole year. Whereas in the dry tropics the soil during periods of drought is often reduced to dust which may be carried away by the wind or eroded by the heavy tempestuous storms which herald the break of the dry weather season, this dusty soil is but poorly absorbent and in consequence it takes little to remove it from its normal situation.

Again, the configuration of the country must be another factor to receive consideration. The steeper the slope, other things being equal, the less the time for water absorption and in consequence the greater the " run-off ". The aspect of the slope is also important, for hilly slopes which face the direction from which prevailing rain storms come, suffer more than those which are favoured by a measure of protection. The size and shape of the watershed also must not be overlooked when the opening of lands from forest or grassland cover is under consideration and a decision being made of the anti-erosion measures to be adopted.

Consideration must also be given to the kinds of vegetation and the extent of the land cover. Forest cover is recognized as affording an ideal protection against erosion. Tree roots bind and hold the soil, leaves and branches break the velocity of the rains which would otherwise compact and erode the soil and the ground cover of forest litter provides that the water is rapidly absorbed, the velocity of surface water from hilly slopes reduced and " run-off " prevented. It is the organic litter in the forest which encourages the absorption of water and checks run-off, but at the same time the more satisfactory soil structure under the forest litter must not be overlooked. Soil under forest cover invariably has a better structure than is the case when a similar soil is subject to cultivation for a number of years.

It should be the aim of all agriculturists in the wet tropics to maintain or to reproduce as far as is practicable the conditions which prevail when the land is under forest cover. Tree crops which produce a good canopy of foilage are more suited for cultivation in these areas than are annual crops which require frequent cultivation. Where the nature of the crop does not permit of forest-like conditions being re-created, the use of contour drains, silt pits, terraces and ground covers is necessary if " run-off " is to be effectively checked.

In effecting control in the use of land so that erosion may be checked it is important to recognize that it is necessary to protect by means of forest reserves or in grassland cover the major catchments and watersheds, provide for the protection of stream banks and steep hill slopes and prevent the destruction of the natural vegetation on the poorer lands.

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In the dry tropics, the position differs from that which obtains in the wetter areas. Here the principal activities which are causing injury to land are shifting cultivation, bush firing, increased agricultural activities and in some places overstocking with cattle and goats. The consequences of the exposure of vegetation to these abuses are a general deterioration of environment, soil degradation, a failure of water supplies and erosion. In many areas in the dry tropics, forest cover is sparse, and in others savannah or grassland prevails. It is only in recent years that grassland problems have been intensively studied in temperate countries and the work has barely begun in the tropics. Data are available which show that " run-off " from grass covered areas is practically nil and that from an erosion point of view they provide efficient cover. In fact it is now recognized that fibrous rooted crop plants are more effective in providing for water absorption than are tap rooted plants and that a good cover of grass will minimize erosion and increase infiltration of water. If, however, these grasslands are, as is so often the case, overstocked with stock concentrations the soil cover is rapidly eaten down or trampled out. Erosion then becomes serious. Similarly, agricultural cultivations in grassland areas can readily become the cause of extensive gully erosion.

The damage which can occur in grass covered country from overstocking or thoughtless agricultural activity can be seen in many parts of East Africa to-day.

In dry areas also much damage is occasioned by the annual burnings which occur. These cause a definite retrogression in the growth of vegetation and the absorptive capacity of the surface soil is greatly reduced.

Wind erosion is severe in only the driest areas and occurs only when the vegetation has degraded or has been removed for agricultural occupation. The loss of soil structure is one of the main causes responsible for making a soil liable to wind erosion. In areas liable to wind erosion measureable improvements can be effected by strip cultivations and by rough methods of cultivation which attempt the burial of but a portion of the crop residues. It is only when the pressure of population becomes considerable that lands in dry areas liable to wind erosion should be taken up for arable cultivation.

Protection cannot perforce be carried to the extreme as the populations must produce their food for subsistence and some money crops wherewith to secure the cash for the purchase of clothing and other requirements. It is therefore now necessary to consider the measures of control against erosion which have been shown to be effective.

MEASURES OF CONTROL

These vary in accordance with the particular circumstances of the case. They have been devised by man to counteract the troubles which follow upon his thoughtless action in regard to land. It is unnecessary to go into them in any great detail in a paper prepared for an audience such as that gathered at this Conference. Neither is it necessary to quote figures from the results of experiments designed to ascertain the amount of soil lost under ranging forms of treatment, nor to list the comparative efficiency of the different methods

of control. Year by year additional data are being added and from the results secured our knowledge is steadily increasing. The whole essence of the problem is to remember that the measures which require to be adopted in any particular area depend upon the special circumstances of the case. Generalizations are dangerous and each area and each problem must be examined in detail before any particular line of action is advised.

In Kenya, for instance, where attention has in recent years been centred on erosion problems, it is recognized that the chief causes of erosion have been the following :—

1. The deforestation of the hill tops and slopes and sides of river valleys.

2. The depletion of grassland cover by reason of a general increase in cultivation.

3. The cultivation of steep slopes.

4. Gross over-stocking in certain areas leading to a destruction of the vegetal cover, and

5. The concentration of stock at and around water supplies, particularly during the dry season.

In any particular area one of these causes may be of more importance than the others, whilst in another area there may be operative a combination of two or more of them. Each cause of erosion demands specific remedies and it is frequently necessray to combine a number together. Progress is often slow by reason of economic and sociological considerations which have to be given most careful thought and consideration.

It has been demonstrated in the United States of America and elsewhere that erosion cannot be effectively checked in areas where the main cause is over-stocking unless and until the number of stock is reduced to the normal carrying capacity of the land and it is clear that in many parts of East Africa similar action will have to be contemplated if the people are to be saved from themselves. In the tropics it is not always easy administratively to secure the adoption of this necessary measure of control because of tribal customs, especially in areas liable to serious outbreaks of epizootic diseases and severe droughts, but it is recognized that it is useless to introduce contour banks or spreading works without controlling the grazing and that one of the most important measures to demand attention in dry land grazing country is the provision of adequate and satisfactorily spaced water reservoirs or dams for the stock in order that they may be spread over a wider area and excessive concentrations in particular areas reduced. Gradually, as economic considerations become more recognized by the people, improvements will be effected and more satisfactory systems of range management introduced. Economic advantages inevitably lead to the adoption of measures which at first are difficult to secure by reason of the conservatism of the people concerned.

The conditions in the wet tropics are different from those in the drier areas such as those mentioned above, as being applicable to Kenya and the endeavour must there be made to reproduce as far as is practicable the conditions which

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prevail in the natural conditions of the forest. Successful agricultural undertakings in the wet tropics, if one excepts the rice cultivations under irrigation, have as I have already mentioned been found to be the tree crops—of which rubber, tea, cacao, nutmegs and oil palms may be mentioned. These form a satisfactory leafy canopy and where they do not, the introduction of shade trees has been beneficial and the establishment of ground covers adopted. The organic litter which is thereby created plays an all-important part in the control of erosion and this supported by such provisions as platform terraces, box terraces, contour hedges, contour drains and silt pits normally ensure a reasonably stable condition.

It is unnecessary to give constructional details of different forms of terraces and pitted contour drains nor is it necessary to refer to the systems of broad base or narrow contour banks which have been employed successfully in undulating country of medium or low rainfall.

The use of contour hedges or contour strips of mulch have been shown to be effective in several areas and I have seen in parts of Tanganyika and Kenya marked improvements follow upon the adoption of the former and in Uganda the advantages of the latter. The use of contour strips of mulches of elephant grass (*Pennisetum purpureum*) in Uganda has also shown an inexpensive method of inducing the formation of terraces on gentle slopes of friable soils.

Strip cropping is also being employed with success. It can be used on moderate and ungullied slopes whilst contour buffer strips of close growing grasses or cover crops are also effective in certain places.

Recent investigations have also shown that roads, paths and fire breaks must receive attention in connexion with any anti-erosion measures and that it is of the greatest importance that most careful consideration be given to the natural drainage channels. The use of vegetation as covers in these water outlets is preferable to the construction of engineering works and the whole tendency of modern thought to-day in regard to anti-erosion measures is to encourage Nature to do her rightful work and to enlist her aid in every manner possible. The aim should be to get away from engineering structures as far as possible and to make the fullest possible use of vegetation. This is the most economical system and produces the most lasting results.

SOIL STRUCTURE

I will now briefly turn to the question of soil structure. Steadily it is becoming recognized that many of our agricultural difficulties have resulted from a loss of soil structure. Sheet erosion, that most insidious form of soil loss, is often unrecognized at the outset. It may not attract attention until finger or other forms of gullies begin to occur. In Uganda, for example, there has been a progressive increase of sheet erosion since the extension of cotton cultivation became general and it is now recognized that, except in a few areas of that country, the soil losses which are being experienced are due mainly to a loss in soil structure.

Soils under forest cover have as a rule a satisfactory soil structure. The decaying roots and the decomposition of the organic leaf-fall are responsible for this, but general conceptions of soils have changed markedly in recent years.

From the geological conception we have been introduced to the biological conception. This in turn has been shown to be but part of the whole story and now our thoughts are being directed to the importance of soil crumb, for without a satisfactory soil crumb water absorption is unsatisfactory, biological activities are affected and fertility reduced. In a soil of good structure the mineral particles are cemented together by the colloids into water-stable crumbs, and where the soil crumb has been lost the soil particles become mere dust which may be blown away by the wind or carried down the slopes by every shower. Optimum crumb size varies with different soils and under differing climatic conditions. It may be defined as that which best secures adequate supplies of air and water for plant existence. In wet climates the limiting factor is the air supply whilst in arid climates water is the controlling influence. It follows therefore that in the wet tropics an open soil structure is preferable whilst in the drier tracts a more compact soil structure is desirable. *Martin* in Uganda is finding that soil structure can be markedly improved in the cotton-growing belt by the use of rotational growths of elephant grass (*Pennisetum purpureum*) between crops of cotton and food crops. He has in fact found the improvement of soil structure is better under grass, with its masses of fibrous roots, than when green manures are employed. Similar results, although perhaps not quite so spectacular, are being obtained in the drier areas where permanent star grasses (*Cynodon* spp.) are being employed in the place of elephant grass.

This work appears to be of importance and it may lead to a definite form of alternate husbandry, with, say, three-year periods of arable alternated with similar periods when the land is under grass. The system is not very different from that which is now finding favour in England where arable cultivations are being alternated with leys of grasses and clovers for periods of three years upwards.

If the results in Uganda come up to expectations, the change of system is expected to find favour, because it approximates in an organized form to the methods of the shifting cultivations in the grass covered areas.

SOIL FERTILITY

Within certain limitations, a soil owes its character rather to the effects of climate and vegetal cover than to the nature of the parent rocks. Removal of cover and exposure to the sun tends to speed up the chemical processes, while rainfall is responsible especially in the wet tropics for excessive leaching of plant nutrients if the soils are exposed.

In the wet tropics, the luxuriance of evergreen vegetation conveys an impression of considerable soil fertility. This has led to the clearing of areas formerly covered with heavy forest for cultivations of both permanent and annual crops. In regard to the latter, many have been the disappointments. Deprived of the products of decay of the forest vegetation the soil has proved to be unproductive and the cleared areas have been abandoned to a useless and often sparse weed growth. *Mohr*, in his article on " Climate and Soil in the Netherland Indies " has pointed out that heavy rainfall causes leaching and impoverishment of the soil. Under virgin forest conditions, plant nutrients

form a kind of closed cycle, whereby the plant food taken from the soil is returned in the form of plant residues; but when that cycle is broken and crops are taken from the land a loss of fertility begins. This loss of fertility may be excessively rapid under the conditions prevailing in the wet tropics and I have seen excellent forest lands opened for pineapple cultivation reduced to infertile white quartz sands within a period of three years.

Hardy has shown in respect of cacao that the chief nutritive feature of organic matter in cacao cultivation is its content of mineral nutrients and that importance should not be placed on nitrogen to the extent to which it was at one time customary. The results which are being obtained from the use of phosphatic manures in rubber cultivations in the East also tend to support this view.

In the drier tropics, attempts have been made to introduce mixed farming, whereby animal husbandry is introduced into the agricultural system of the small-holder for the purpose of producing supplies of organic manures. In Northern Nigeria progress has been made, but here again except for the value of the organic matter in the building up of soil structure it has been determined that the increases of crop yields have resulted from the phosphatic nutrients of the manure added. Attempts are being made to encourage the spread of mixed farming in many parts of the British Colonial Empire and large numbers of experiments are being carried on. It has yet to be ascertained whether the system can be introduced effectively into the wet tropics where, as has been previously stated, it is now recognized that permanent tree crops are more suited to the prevailing conditions than annual arable cultivations.

Trials are also being made with the use of composts. Their value has been demonstrated in nursery work and in garden cultivations but it is doubtful if the preparation of composts is economically sound for large scale cultures, especially in areas where the rainfall is adequate to ensure a satisfactory break down naturally of organic waste materials within a reasonable measure of time. In the dry areas, the position may possibly be somewhat different if adequate water supplies are available for the making of good composts. From a soil erosion point of view, however, it must not be overlooked that vegetable wastes and stubbles can be usefully employed as part of anti-erosion measures. I would be very loath to see, as I have done recently in Ceylon, the general adoption of a system of clearing undulating land free of waste vegetable matter for conversion into compost to be transported back to the area from whence it came. This is a most wasteful method and one which is liable to encourage an increase of erosion.

With the use of green manures considerable successes have been achieved in the Netherland Indies but our experiences in the British colonial dependencies have been variable. In Ceylon and Malaya their use has been advantageous and in Nigeria it has been demonstrated that soil fertility can be maintained at a reasonable level by their use. In East Africa, however, their use has not brought about the results which were expected and except where pigeon pea (*Cajanus cajan*) is being employed for the breaking up of lateritic hard pans there is a tendency now to await the results of the experimental work designed to test whether the improvements of soil structure

which result from land being sown or planted with grass as part of the rotation are not of greater value than those which follow upon the employment of green manuring. A strong cultivation of grass or a healthy grass sod produces new roots each growing season to replace the older ones which in their turn add to the soils organic matter. When land is under a grass sod the organic matter in the soil is increased and workers with sugar cane in Hawaii hold that the amount of roots annually produced by a crop of sugar cane adequately maintain a soil's organic matter content. I am aware of lands in British Guiana which have been under sugar cane continuously for nearly 100 years, with only those breaks at intervals of 3–4 years when replanting had to be done. Grassland soils are generally richer in organic matter under comparable conditions than are forest soils and we are, I fear, rather inclined to overlook that the grass lands which are associated with the dry tropics often mean poor soils because of low rainfall and stunted growth of the vegetation rather than an intrinsic harmfulness which has so often been ascribed to the grasses themselves.

CONCLUSION

In conclusion, I would like to say that I have endeavoured to treat this subject of soil conservation, which is attracting world wide attention, in as comprehensive a manner as time permits. Science in recent years has tended to become departmentalized into a series of narrow specialist channels. Co-ordination is often difficult to secure and a clear picture of the whole impossible to obtain. It is the same with matters concerning soil conservation. There are the enthusiasts for certain particular remedial measures and also those who tend to ride their pet hobby horses. But we must approach the subject from a much wider view-point if sound progress is to be attained.

Much time, energy and money has been expended in many countries on the treatment of gullies which are but the indications of troubles further away at the head of the drainage systems. Similarly much time and energy has been expended on the development of terraces, contour bundings and other works in areas where the methods of agriculture are faulty.

One knows full well that circumstances in many tropical countries demand immediate and energetic action if increasing losses from erosion are to be checked and ultimate economic ruination prevented. Sound planning of land usage is essential but without sound methods of agricultural husbandry and range and woodland management attempts to check erosion will be of but temporary value. Soil conservation in its truest sense will not be achieved unless it is tackled in the widest possible way. The building up of deteriorated soils is a relatively slow process for soil building and can only be effected if an increase in the organic matter is secured. If this can be accomplished other effects, physical and chemical, will follow.

The present position demands firstly that the rot which is at present occurring in many areas should be stopped and that at the same time strenuous attempts be made to build up sound agricultural practices. The marriage of animal husbandry with crop production must be achieved in all areas where the conditions are suitable and where they are not, crop production must proceed along lines which conform with the dictates of Nature.

In the Netherland Indies, the planned utilization of land has long been the basic policy of the Government and it has long been recognized that agricultural practices should conform to the needs of the land.

It should be our endeavour to foster in every way possible and in the widest circles this thought for the land. Erosion can be controlled if Nature is carefully studied and her secrets ascertained. The land is the chief asset of the tropical peoples and the proper use of that asset by present generations combined with its conservation for those to follow should be the primary aim of all.

Exploitation of soil fertility has gone far enough in many areas, whilst in others it has gone too far. A full stock of the position is now being undertaken and it is to be hoped that all who can will add their quota to the endeavour necessary to improve matters.

TOMATO CULTURE*

(Some important parts of the article are applicable to colder climates than Ceylon enjoys. But the article is reproduced because the other parts are likely to be useful to tomato growers in Ceylon—Ed.).

COMPARED with other branches of fruit culture the tomato industry has made amazing progress in the commercial fruit-growing world. Less than 400 years ago, the tomato (*Lycopersicum esculentum*), a native of tropical America, was almost unknown. It belongs to the genus Solanum, which includes the Deadly Nightshade and other poisonous plants and at one time the tomato was thought to be poisonous. Actually, the leaves and the stems of the plant are poisonous, but the fruit is not. In fact, it is a very wholesome article of diet. The tomato has now been introduced into most parts of the civilized world.

Eleven years ago (1927), the total commercial acreage of tomatoes in Victoria was computed to be approximately 15,000 acres, with an estimated yield of 800,000 cases valued at £200,000, and the value of the output of the eleven foremost factories, where tomatoes were processed, was approximately £300,000. The tomato industry in Victoria was then estimated to be worth £500,000. Accurate figures are not available to show the enormous increase which has taken place in the industry since that time, but the production from one district, namely, Portland, may be of interest—In the year 1927 the output of tomatoes from Portland, in the height of the season, was approximately 500 cases per week from a radius of approximately two miles. To-day (1937–38) the district extends more than 25 miles and the output has arisen to approximately 15,000 cases per week, returning the district approximately £40,000. A yield of 600 cases per acre is considered a fair estimate, but 1,000 cases, and occasionally more, have been produced.

Dimboola is another district which was practically unheard of in the tomato-growing world ten years ago, but to-day it is impressing itself on the markets. At Shepparton, the area has increased to such an extent that three factories dealing exclusively with tomato pulp have been established. Other districts previously unrecognized for tomato culture are also rapidly developing. Among these are Robinvale, Pomonal and Mildura. In the latter district there are already a dozen or more glass houses each 100 feet long by 15 feet wide.

Soils.—The tomato is cosmopolitan in its requirements regarding soil. It can be commercially grown on many soil types, from clay to comparatively light sands. Soils of low fertility require fertilization to produce the best results. Examples of good tomato soils in Victoria are, the Murray river silts, the sedimentary soils of the Goulburn Valley, the alluvial loams of Bendigo,

* By Basil P. Krone, Fruit Packing Instructor, In *The Journal of Agriculture* ,Victoria, Vol. XXXVII—Parts 2, 4 and 6, February, April and June, 1939, respectively.

the light loams near Burwood, the red loams and light sands of the Mornington Peninsula, the silurian soils near Pomonal, and the black peaty loams, the red buckshot loams and sandy soils of Portland. Tomatoes grown on all these soils produce good crops. The yield of the Chinese types can be estimated at 600 cases per acre when grown on any one of them.

Whatever the type of soil, the most important feature is its physical condition. A good humus content, high fertility, and good drainage of both the soil and subsoil are desirable. These features result in a more even temperature and moisture content in the soil under varying climatic conditions than would otherwise occur. Good drainage is so important that where one is in doubt it would be advisable to dig a few small holes about 18 inches deep on different parts of the proposed plot. Should these hold water longer than say twelve hours after a heavy rain, underground drainage is recommended.

No matter what class of soil is being used a plentiful supply of humus is necessary. If this cannot be maintained by the addition of stable manure, then rotation of cover crops should be practised. The depletion of humus in a soil through continuous cropping is frequently a cause of decline in production. Where a grower has free access to river flats, the fertility of a sandy soil can be greatly improved by top-dressing it liberally with the heavier loams, which are frequently of a silty or clayey nature, rich in potash and humus. Of course, only the surface soil should be used, such as that obtained by shallow ploughing, to facilitate its easy removal.

Drainage.—Most soils, in which it is intended to grow tomatoes, require underground drainage. The necessity for this may be determined by the method described in the previous section dealing with soils. Underground drains produce a more even temperature and more uniform moisture content in the soil; this is most important for tomato culture. Blossom end rot and other physiological troubles are known to be aggravated by irregularities of soil moisture, together with other extremes in climatic conditions. In addition, many surface soils overlie tenacious clay subsoils, which retain excess water for long periods, or the subsoil may be of a cement-like formation known as hardpan. This comparatively thin, though impervious, strata should be broken up by subsoiling, and vegetable matter, such as strawy stable manure or even very small branches from bush timber, can be incorporated in the soil to prevent these layers from consolidating again.

Underground drainage is the only satisfactory method of improving badly drained land; surface drainage is not sufficient. It is recommended that short underground drains with pipes 2½ to 3 inches in diameter and 25 or 30 feet apart be placed between 3 and 4 feet deep, keeping in mind that short deep drains are always more efficient than long or shallow drains. It may be argued that drains much shallower than those stipulated are satisfactory, but in the writer's opinion, the deeper drains are better, particularly under irrigation conditions.

Sowing the Seed.—Tomato seeds should be sown very thinly, either in trays of light, but not necessarily rich, sandy soil, or in shallow drills in a sheltered seed bed.

In a hot-bed the seed is frequently broadcast, or drilled thinly, about 4 or 5 seeds to the inch being ample. Another method is to broad-cast the seed in one corner of the hot-bed and prick the seedlings out, just before the first pair of rough leaves appear, into the other part of the hot-bed, in rows about 4 or 5 inches apart, and 2 to 3 inches between the plants. Each row of little plants should be very slightly " hilled " to facilitate even distribution of water.

In the writer's opinion the best method is to broadcast the seeds in trays, and prick the seedlings out into other trays later. This facilitates transportation to the field at planting time without check to the young plants.

Where a very large acreage has to be planted, perhaps by a planting machine, one of the other methods described might be preferable, because, unfortunately, the earth has to be shaken from the roots before being planted by the machine. However, the method chosen can be decided by personal requirements. A machine plants approximately 15,000 tomato plants per day of eight hours. It is considered a very good day's work for one man to plant 1,000 plants.

Whichever method is adopted for sowing the seed, it should be covered with a thin layer of sandy soil not more than a quarter of an inch thick, or better still, a 50–50 mixture of leaf mould and sand which has been screened, or its equivalent, in order to prevent the surface cementing, cracking or drying out. The bed should then be gently watered, and if the weather is warm and the surface inclined to dry too quickly, damp newspaper, hessian, or bagging should be placed on the surface for a few days until germination is almost complete. As soon as the little plants appear, they should be thinned out to stand about half an inch apart, although in commercial practice they are usually pricked out into other trays as soon as they are large enough to handle.

When a hot-bed is not available, satisfactory results can be obtained by choosing a sheltered and sunny northerly aspect for the trays or seed bed. This provides maximum sunshine from early morning until late afternoon. The ideal situation is one that would give an even temperature of 70°F., but without the aid of artificial heat this is difficult to obtain. A warm northerly aspect can be artificially created by placing a low temporary wall of galvanized iron, wood or other material on the south side of the bed. Short walls across the east and west ends, say about 2 feet 6 inches wide, together with a narrow roof the same width makes the situation ideal. This would be the best method to adopt in the absence of a glasshouse.

The Hot-bed and Cold Frame.—Hot-beds or cold-frames are very easily constructed and may be made almost any size to suit the requirements of the grower. The hot-bed consists of a layer of soil spread over the top of a compacted heap of fresh, strawy, stable manure, which generates heat by decomposition. If a large quantity of stable manure is difficult to procure it may be wholly or partially substituted by mixing with it, or using alone, a load or two of peas or beans which have been grown as a cover crop, or in fact any other green herbage. In viticultural areas the waste stems from the dried fruit, if slightly dampened with hot water to facilitate the heating process will give excellent results.

Location, size and accessibility of the hot-bed or cold frame are important considerations. The length is immaterial, but useful widths are 6 feet or 8 feet for the gable type, and 3, 4 or 5 feet wide for the skillion type. To obtain maximum sunshine the gable type should always run north and south and the skillion type east and west with its sloping roof facing the north. A bed, say, 20 feet long by 8 feet wide will accommodate 3,200 plants when pricked out, approximately half an ounce of seed being required to provide this number of plants.

Construction.—To construct a hot-bed 20 feet long by 8 feet wide, build four walls (old galvanized iron or wood will be suitable) 18 inches high and of the size mentioned, and fix a good wide ridge board (piece of 3 in. × 2 in.) on its flat, on top of five short uprights, size 3 in. × 3 in., spaced 5 feet apart from centre to centre, and gable shape roof will be formed when the glass frames are resting on top. Into this, and to a height of 8 or 9 inches add sufficient fresh strawy stable manure which has been previously turned over several times with the fork and covered with old bags for a few days. Compact it thoroughly by tramping, then level it off. It is important to note that the thickness of the layer of manure should not be less than 8 inches. Spread over this a layer of good garden loam about 4 inches thick which has been screened and made friable by the addition of sand and leaf mould. A very fertile soil is not necessary for the hot-bed, but it must be sandy to develop a good root system. A glass cover for the top and thick bagging sewn together to cover the glass each night completes the hot-bed.

The cold frame is similar in construction to the hot-bed, but is without bottom heat. It is necessary, however, that the soil for this frame and/or trays be a very fertile one. A fertile soil can be artificially made by mixing together three parts of ordinary garden loam, two parts of very old pulverized cow manure, or sheep manure for preference, and one part of sand.

Both the hot-bed and the cold frame are in reality miniature glasshouses, and, therefore, should be treated as such. This means that temperature, ventilation, and evenness of soil moisture should receive constant attention.

Ample ventilation must be provided at all times without admitting draughts or cold winds. The glass should be well raised on sunny days. Lack of ventilation and excessive watering will quickly cause "damping off" or overdrawn seedlings.

The best guide is a thermometer, the temperature being kept as near as possible between 65° and 72°F. Serious harm, however, will not occur in a cold frame should the temperature occasionally fall as low as 50°F., which it might do for a few hours on a cold night. In the hot-bed high temperatures are detrimental in the cold weather, but are not so harmful as warmer weather approaches. The temperature can be kept fairly uniform if the glass is raised or lowered according to the vagaries of the weather.

Covering the frames each night is a very important factor. Failure to do this on a frosty night will convert the frame into a veritable ice box and destroy the plants, also continual watering with very cold water in the winter time on soil

which is already damp is decidedly detrimental. In the writer's opinion, seed beds or trays should be allowed to appear as though they were commencing to dry out but not actually dried out, before applying water, and in the *cold weather*, if cold tap water is to be used, better results are obtained if the watering is given in the late morning rather than the evening. On the other hand where evening watering is desirable tepid water not warmer than 100°F. is satisfactory. In fact, tests have proved that, where plants are raised early in the season without a glasshouse, they are several days earlier when watered with tepid water all the time than when cold water is used. The ordinary watering-can with a coarse nozzle is not suitable for seedling tomato plants. Seedlings require a fine misty spray and special cans can be procured for this purpose.

Seedlings and Trays.—As previously explained, the seedlings should be pricked out 2 to 3 inches apart, from where they have been sown, into other trays, or a cold frame, before the first pair of rough leaves appear. This work usually takes place a fortnight to three weeks, according to temperature, &c., after sowing the seed.

Some growers do not prick out their seedlings. They simply pluck up handfuls of the young plants later and " heel " them in for a few days to harden off just prior to planting. This is not a good method, because not only do the plants receive a severe check, but also large numbers become overdrawn through growing so closely together. The extra work of pricking out will be amply repaid by the sturdy class of plant that is obtained.

During the months of August-September the outside temperatures fluctuate between 45°F. on cold nights to 120°F. in selected sunny positions in the day time, and tests have shown that seeds sown in trays or cold frames during this period require approximately ten days, according to the variety, to germinate, while where the temperatures are controlled, say in a glasshouse with a minimum of 60°F. and a maximum of 75°F., the seeds require only five to seven days to germinate. Later, and when the plants are in the field, they appear to thrive better when night temperatures do not fall below 60°F., and the day temperatures are around 80° to 90°F., but, of course, these congenial conditions do not occur until later in the year.

In the trade, trays of uniform size are used, and where thousands of seedlings have to be handled, the " pricking out " is done only a trifle closer than that recommended in the chapter relating to this work. Trays in two sizes are used ; the larger are 28 inches long, overall, by 14 inches wide inside and 3 inches deep inside, with a partition across the centre. These accommodate 200 plants. The smaller tray, which accommodates 100 plants, is half the size, namely $28 \times 7 \times 3$ inches with a partition.

Planting Out—Staking.—The little plants should be planted out any time after they have made their eighth leaf, but preferably just before the tenth leaf appears. The period from the time the seed is sown to this stage will vary from six to eight weeks according to temperature and growing conditions.

After the tenth leaf has formed most varieties produce the first set of flowers, then five leaves and another set of flowers, then three leaves and a set of flowers alternately, during the life of the plant. There are very few exceptions to this

rule. Those which differ have what is known as a determinate habit of growth. They are sometimes called "self-pruners" because they produce a set of flowers between each leaf stem and terminate with a set of flowers instead of a lateral growth. A variety with these characteristics was produced in 1931 or 1932 by Dr. O. H. Pearson, formerly of the Californian Agricultural Experimental Station, and named after him. Another American variety named Penn State also has these characteristics.

Planting-out time is a critical stage in the life of the tomato plant. It is most important that favourable weather conditions accompany the work. Should cold winds prevail, the grower will achieve better results if he delays the planting until a more favourable time, even if he has to wait until the little plants are forming the first set of flowers.

Plant the young plants deeply; to the first pair of leaves is recommended. If the plants are to be grown in the bush form, dwarf varieties such as Burwood Wonder, or the South Australian Dwarf may be planted from 18 inches to 2 feet 6 inches between the plants and 4 feet 6 inches to 5 feet between the rows. Other varieties (not cluster types) should be planted from 2 feet 6 inches to 3 feet between the plants and 5 or 6 feet between the rows.

Cluster types, also other varieties which are to be staked, may be planted from 1 foot to 15 inches apart and 4 feet 6 inches or 5 feet between the rows. A good method of staking is to plant two plants about 6 inches apart with a stake between them, leaving a slightly larger space, say, 18 inches before planting the next two plants. This method reduces gaps in the row should a plant die from disease.

Another satisfactory method which is becoming more popular is to strain two fencing wires, one about 6 inches and the other about 5 feet from the ground, the whole length of the row between two heavy strainer posts. Stability between the two wires is maintained by driving light wooden droppers into the ground at intervals and fixing the wires to them. Hayband is then tied or wound up and down between the wires, and the plants trained to this instead of wooden stakes. At the end of the season the haybands are simply cut, the old plants pulled out, heaped up and burnt. This system is claimed to be more economical than the usual method of staking. In all instances the distance between the rows is decided by the ultimate size of the variety, ample space being left for cultivating implements to pass through.

Lossess at planting time are sometimes due to obscure causes, therefore the following recommendations are made :—

(*a*) Always wash the hands before handling young tomato plants if artificial fertilizers (particularly superphosphate) have been previously handled. Artificial fertilizers must not come in direct contact with any part of the plant; not even the roots at planting time. This will be dealt with later.

(*b*) Do not allow the foliage of the small plants to become wet while planting out. Do not dip the foliage in water or other solution. The young plants should be certainly watered in, but the rose of the watering-can should be directed to the sides of each plant and not over the top of them. Moisture-laden leaves in uncongenial weather fall flat to the ground and stay there for

so long that before the plant has time to recover from the shock of transplanting, normal functioning of the leaf ceases, and results in either a weak plant or its complete collapse.

(*c*) A well prepared soil in a nicely compacted seed bed should be the future home of the young tomato plant. An insufficiently compacted soil, or seed bed, is frequently the cause of many failures. The land should be prepared months ahead.

Irrigation.—Over-irrigation ruins the quality of tomatoes. An attempt should be made to maintain evenness of moisture and good physical condition of the soil by judicious watering and generous cultivation.

Cultivation should follow every irrigation, but care should be taken not to cultivate too deeply close to the plants, otherwise more harm than good will occur through injury to the feeding roots. To achieve this objective the grower should regulate the frequency of the irrigations according to local conditions, such as annual rainfall and the type of oil, &c. Irrigations should be used only to prevent the plants from wilting ; but at the same time the conditions should be such that they are kept steadily growing. Tomatoes like moisture, but there is a difference between a moist soil and a wet soil ; they will not thrive in a wet soil. Tests with tomatoes from irrigated areas have revealed that over-irrigated fruit may contain only 3 per cent. solids, while the same variety, under correct treatment, would contain 6·3 per cent. solids.

It is difficult to describe a standard which could be used as a guide to the desirable soil moisture content of a soil. The following might be an ideal to aim at, and convey some idea of this very important feature :—Although the soil should not be continually wet, it should never become so dry that it crumbles if squeezed together in the hand. Let us say " when not more than approximately 50 per cent. of the spaces between the soil particles are filled with water ", or again may we liken it to a wet towel which has been " wrung out ". Vagaries of climatic conditions will always play an important part, but if this idea is followed there will be fewer complaints from factories about watery tomatoes.

Manures.—The fertilization of soil for tomato plants is sometimes a vexed problem. There is no known substance that will improve a soil better than natural animal manures. They not only supply the various plant foods, but improve its physical condition by the addition of humus, resulting in better aeration and improved moisture holding capacity. Stable manure might be termed the ideal complete fertilizer. Of course stable manure is not always available in sufficient quantities, and then artificial fertilizers have to be used. If their use is not thoroughly understood by the grower, the maximum results will not be obtained.

The experienced farmer knows that *well decomposed* stable manure can be applied safely to any soil ; in fact, there is scarcely a soil-type that it will not benefit. Unfortunately, the same remarks cannot be applied to the indiscriminate use of artificial fertilizers, and these good results are not always possible on some soils with certain of these fertilizers.

The chief artificial fertilizers used for general farming are superphosphates—supplying phosphoric acid ; sulphate of ammonia or nitrate of soda—supplying nitrogen, and sulphate or muriate of potash—supplying potash. When these fertilizers are applied in combination, such as, for example, the 2 : 2 : 1 mixture, they are also known as a complete fertilizer, *viz.*, 2 parts of super., 2 parts of sulphate of ammonia, and 1 part of potash, but there is a difference in the results obtained when each of these types of complete fertilizers are compared in the field.

What is this difference ? It is simply this : We are apt to forget about the humus which is lacking in artificial fertilizers. Applications of 8 to 12 cwt., per acre of 2 : 2 : 1 mixture might be used with excellent results on soils well supplied with organic matter, but where this is deficient, humus must be included in the form of cover-crops or supplied from other sources. Artificial fertilizers without humus may be likened to a person taking a tonic, without food in which " bulk " is so necessary to maintain health.

Frequently, artificial fertilizers are not applied deeply or early enough. Most fertilizers should be applied at least three weeks before planting, and placed deeply enough to be within the root zone of the plants.

Blood and bone, superphosphate and potash are the chief artificial fertilizers for tomatoes. Heavy applications of quick-acting nitrogenous fertilizers, such as sulphate of ammonia or nitrate of soda, cause splitting or softening of the fruit of some varieties of tomatoes. There are, of course, occasions when the application of one or more of the latter ingredients as a side dressing would be warranted.

For general purposes, the following suggestions may be useful :—Mix together six parts superphosphate, four parts blood and bone or abattoir manure, and one part of potash. Use a double handful of this mixture for each six or eight little plants at least three weeks before planting time. On some types of soil the proportions of blood and bone, and superphosphate given above may be interchanged with excellent results, also in some districts potash may be eliminated because there are large amounts of available potash already in the soil.

In the Goulburn Valley applications of gypsum, at the rate of at least 2 tons per acre, frequently give very good results owing to the improvement brought about in the physical condition of the soil. It is possible that it also makes available portion of the abundant supply of potash present in these soils. Again, sulphate of ammonia or nitrate of soda would be more useful on light sandy or gravelly soils, *e.g.*, around Pomonal and also in parts of the Portland District. If the soil is inclined to be alkaline, sulphate of ammonia should be used, as it tends to make the soil more acid. Blood and bone, abattoir manure, castor meal, and cover crops should not be overlooked in the fertilizer programme, especially in the light sandy soils or loams deficient in organic matter.

Fertilizers should be thoroughly mixed with the soil or placed beneath the plant in such a manner that they will not come in direct contact with the roots. This can be most easily achieved when " hilling " up the lands, which usually consist of four furrows, by casting the required amount of fertilizer along the

bottom of the third furrow and stirring it in the lower soil before the fourth furrow is thrown on top of it. The plants are later planted over this furrow. For wider plantings in non-irrigable districts the appropriate planting furrow should be used instead of the third one.

Another method is to drill the fertilizer in at the rate of 8 to 12 cwt. per acre over the whole area a few weeks before planting. If a side dressing of a quick-acting nitrogenous fertilizer is to be used, it can be applied after the first set of fruit has formed by watering it in with an irrigation, taking care not to let it come in direct contact with the leaves or plant. A mixture of from six to three parts of super-phosphate, according to district, and one part sulphate of ammonia, is recommended for the purpose, and generally gives excellent results.

Superphosphate usually gives good results when applied to tomatoes, but in some districts it does not, therefore, in such instances the quantity of super-phosphate should be decreased and the quantity of blood and bone increased. The 2 : 2 : 1 mixture, previously referred to, also gives good results, and where one is not certain which manure to use, money would be more wisely spent on this complete mixture than by taking a chance with any single fertilizer.

Lime is seldom necessary in tomato culture. Soils showing pH reactions of 6·5 to 7·0 would appear to be the best for tomatoes, but good crops frequently are produced on soils which are more acid or less acid than this range. One of the best uses for lime in tomato culture is its application on the land prior to sowing a cover crop. It has a special influence in the growth of peas and other legumes. Cover crops improve the physical condition of the soil and thus, indirectly, improve the growth of the tomato plant.

If fertilizers (and lime) are to be used singly, it is recommended that they be applied as follows :—

Lime.—Although not a fertilizer, should be applied in the autumn.

Blood and bone or Abattoir Manure.—In the very early spring, or a couple of months before planting out.

Sulphate of Potash.—A month before planting.

Superphosphate.—A week before planting, at planting time, or with ammonia as a side-dressing.

Sulphate of Ammonia or Nitrate Soda.—As a side-dressing after planting, and as soon as the first fruit has set. An excellent method with this fertilizer is to water it in.

Pruning.—Pruning the tomato plant is really a simple procedure. By careful observation, almost any one could carry out the necessary work in a satisfactory manner, but the nature of the numerous varieties should be first understood so that they may be treated according to their respective habits. To do this, tomatoes should be classified into three groups, namely :—

Chinese or Crinkled Types.—These include the rough, flat, crinkled, or corrugated varieties such as Australian Large Red, Burwood Wonder, &c. Such varieties are noted for their good cropping habits, suitability to most soils

and locations, and marketable size of the fruit without pruning. Chinese types, unfortunately, are not noted for high quality fruit, nevertheless, they serve a useful purpose. They should be grown in the bush form and unpruned, except in glasshouses, or in the home garden, when pruning to one or two leaders, on stakes, is advised. Economics are the deciding factor for pruning. For home garden purposes, the plants are better when kept off the ground by staking. They are also more readily accessible for cultivation, &c.

Smooth Globe or Canning Types.—These varieties are not usually such heavy croppers as the Chinese kinds. Indeed, some are particularly shy, and vary in their preference to soils and location. Some, however, are entirely satisfactory, and should be grown without pruning and in the bush form, while others are better when pruned heavily to a single leader on stakes. Others, again, are more satisfactory when two or more leaders are adopted. Some varieties in this group are noted for the outstanding colour and quality of the flesh for factory purposes and for the table. To the enthusiastic home gardener, they are a delight to grow. An increased number of good cropping varieties is being established each year.

Dessert or Cluster Types.—Varieties in this group are by far the heaviest croppers. They are so prolific that, if left unpruned, they will produce fruit as small as marbles, therefore, it is important that these should receive special treatment. The cluster types are not satisfactory unless heavily pruned to a single leader and stake, and the clusters of fruit thinned as soon as possible after the sets have formed. To do this, the terminal fruits should be discarded, retaining those nearest to the main arm. The soil should be heavily impregnated with very old cow or sheep manure, and in addition, the plants should be side-dressed with artificial fertilizers.

From the above, it is readily seen that it serves no useful purpose to prune some varieties too heavily, as the fruit reaches normal size with ordinary methods of good tomato husbandry.

Pruning consists of pinching out the lateral growths as soon as they appear in the axils of the leaves. This practice should be modified according to requirements of the variety and habit of the plant. At the same time, it should be observed that the "sets" of flowers do not emerge from the base of the leaf stems, such growths are new laterals coming into existence, and these frequently confuse the beginner. The first set of flowers emerges directly from the main arm, usually midway between the tenth and eleventh leaf. In calculating this, allowance should be made for the early leaves, which frequently fall after planting-out time. The second set of flowers emerges likewise, but between the following fifth and sixth. Each successive set of flowers then emerges after each succeeding third leaf during the life of the plant.

If the laterals are allowed to develop, they also grow into main arms, and sets of flowers are produced on each of them in a similar manner to that described, except that they appear after every third leaf from the base of the lateral. With this in mind, and the knowledge that one variety may be of the small dessert or cluster type, and another a larger canning variety, the grower can modify his pruning accordingly.

There are, of course, varieties which are exceptions to the foregoing statement, therefore, to avoid confusion, tests have been made, and a list of varieties of " Tomatoes of Outstanding Merit in Victoria, and How to Grow Them ", is published elsewhere in this article.* The reader is advised to note the recommendations before commencing to prune. Many disappointments have ocurred in Victoria through the misapplication of staking and pruning, with the result that some good varieties, especially the cluster and canning types, have been unjustly condemned.

Pruning tests have shown that it does not pay to prune unstaked plants to encourage early maturity of the fruit. If varieties are to be pruned, it is better to stake them, disbud the laterals according to requirements, and stop the main leader after the third or fourth set, or when the plant reaches the top of the stake. Any yellow leaves that appear should be cut off and burnt.

Not reprinted.

MEETINGS, CONFERENCES, &c.

COCONUT RESEARCH SCHEME

BOARD OF MANAGEMENT

MINUTES OF THE FORTY-SIXTH MEETING OF THE BOARD OF MANAGEMENT, COCONUT RESEARCH SCHEME, HELD IN THE LIBRARY, BANDIRIPPUWA ESTATE, LUNUWILA, ON TUESDAY, JUNE 20, 1939, AT 10 A.M.

Present.—Mr. E. Rodrigo, C.C.S., Acting Director of Agriculture (in the Chair); Mr. C. H. Collins, C.C.S. (Treasury Representative); Mr. O. B. M. Cheyne; Mr. A. Ekanayake ; Mr. James P. Fernando ; Mr. D. D. Karunaratne, J.P. ; Mr. G. Pandittesekera, J.P., U.P.M. ; Mr. H. W. Peiris ; Mr. L. J. M. Peiris, M.B.E., B.A. ; Mr. E. R. Tambimuttu, M.S.C.

Dr. R. Child, Director of Research, acted as Secretary, and Mr. W. V. D. Pieris, Genecticist, and Dr. M. L. M. Salgado, Soil Chemist, were present by invitation of the Board.

MINUTES

The minutes of the previous meeting held on Wednesday, April 19, 1939, which had been circulated to members were confirmed.

BOARD OF MANAGEMENT

The Chairman reported that Mr. O. B. M. Cheyne had been re-nominated as representative of the Planters' Association of Ceylon for a further period of three years from June 1, 1939.

STAFF

(*a*) The Board approved of study leave being granted to the Geneticist.

(*b*) *Leave Conditions of Junior Staff.*—The following amended leave conditions for the junior staff were approved :—

(i.) Junior officers will be eligible for the following leave :—

(*a*) 14 days casual leave.

(*b*) 14 days vacation leave, which must all be taken together and for which the officer must actually leave the station for a change.

(*c*) The usual public holidays at Christmas, plus three religious holidays according to the officer's denomination.

(*d*) Sick leave may be granted up to one month in any year on full pay ; and any extension beyond one month to be at the discretion of the Board.

(ii.) One return holiday warrant may be issued for the officer and his family at the time when the vacation leave is taken.

FUTURE OF THE SCHEME

The Board considered the memorandum prepared by the Director of Research on the financial position of the Scheme. After a long discussion it was decided

that the Chairman should prepare for consideration at the next meeting of the Board a statement showing the nature and scope of the work that the Board should undertake in the future and the annual income required for that work so that the Board might make a recommendation to Government for making financial provision for the Board when the present annual subsidy is discontinued in 1941.

MR. MENON'S PROGRESS REPORTS

The Chairman said that two reports had been circulated covering the periods August to December, 1938, and January 1 to April 30, 1939. These reports had also been sent to the Coconut Board.

It was decided that the Board of Management had no objection to the publication of these reports, and that the Coconut Board should be so informed and asked for their views on publication.

BUILDINGS SUB-COMMITTEE

The minutes of the sixteenth meeting of the Buildings Sub-Committee held on May 16, 1939, had been circulated.

The Chairman reported that since then the Committee had approved of the estimate for the Circuit Bungalow and Field Laboratory at Ratmalagara Estate. The work was in hand.

The Board approved of the action of the Sub-Committee.

OTHER BUSINESS

Soybeans.—Mr. Cheyne inquired whether a trial of soybeans could not be made at Ratmalagara estate. The Chairman replied that the question of trying out soybeans had been discussed with the Director of Research and it was intended to plant small areas at Ratmalagara.

Employment of Temporary Clerk.—The Board approved of the employment of a temporary clerk for three months in the first instance to undertake the work of typing the Bibliography prepared by the Geneticist.

The meeting adjourned at 12·15 P.M.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD IN THE COMMITTEE ROOM OF THE CEYLON CHAMBER OF COMMERCE, COLOMBO, ON THURSDAY, JULY 13, 1939, AT 2.30 P.M.

Present.—Mr. James Forbes (Chairman); The Director of Agriculture (Mr. E. Rodrigo, C.C.S.); The Chairman, Planters' Association of Ceylon (Mr. C. W. M. Davies); The Chairman, Ceylon Estates Proprietary Association (Mr. C. H. Bois), Messrs. I. L. Cameron, J. D. Hoare, J. C. Kelly, T. B. Panabokke, S. F. H. Perera, Gordon Pyper, and Dr. R. V. Norris (Director and Secretary). Dr. C. H. Gadd (Mycologist) also attended by invitation.

A letter was received from Major J. W. Oldfield regretting inability to attend.

1. The Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board held on March 31, 1939, were confirmed.

3. MEMBERSHIP OF THE BOARD AND COMMITTEES

(i.) *Board.*—Reported that Mr. C. H. Bois, had become an ex-officio Member of the Board as from April 20, 1939, on his election to the Chairmanship of the Ceylon Estates Proprietary Association, *vice* Mr. R. J. Hartley (Letter dated April 20, from the Secretary, C.E.P.A.)

The Chairman welcomed Mr. Bois and also Mr. C. W. M. Davies, Acting Chairman, P. A. of Ceylon. A vote of thanks to Mr. R. J. Hartley for his services to the Institute was recorded.

(ii.) *Estate and Experimental Sub-Committee.*—The Chairman referred to the fact that Mr. C. Huntley Wilkinson, who had been a Member of this Committee since its inception and who had also served on the Board and as Chairman for a short period in 1929, was shortly retiring from Ceylon. Appreciative reference to his keen and valuable services had been made at the last Meeting of the Experimental Sub-Committee and he thought the Board would similarly wish to record their grateful thanks to Mr. Wilkinson for all he had done to further the work of the Institute. This was agreed to with acclamation.

4. FINANCE

(i). The Accounts to May 31, were accepted.

(ii.) *Additional Votes, Research.*—The Board approved of the following additional votes :—

Revenue Account.—Vote 31, Field Experiments, Plant Physiologist—Rs. 600 being cost of importing varieties of tea seed for selection experiment.
Vote 74, Conference Expenses Rs. 327.

Capital Account.—Guest House Rs. 150 to Colas approach road.

5. ST. COOMBS ESTATE

6. MINUTES OF THE EXPERIMENTAL AND ESTATE SUB-COMMITTEE MEETING HELD ON JULY 8, 1939

At the suggestion of the Chairman, the above two items were considered together.

The following votes, recommended by the Experimental and Estate Sub-Committee were approved :—

Estate Working Account.—Vote 34, Poria Control, Rs. 100.

Vote 33, Illuk and Couch, Rs. 100.

Capital Account.—Vote 73, Machinery, Rs. 1,000 for purchase and erection of a circular saw.

Vote 81, Soil Erosion, additional vote of Rs. 300 for work on the clearings was approved in principle, to be finally sanctioned by Chairman if required.

Manufacture.—The Chairman called attention to the very interesting Report attached to the Minutes of the Experimental and Estate Sub-Committee on the recent sale of T.R.I. Clivemeare tea in London and invited the opinion of the Board on the recommendation of the Committee that as a *temporary* measure the whole of St. Coombs crop should be manufactured by this process so that six further breaks could be sent for sale in London. These invoices would be sold under St. Coombs mark and a satisfactory indication should thus be obtained as to the market's opinion of this type of tea. If favourable results be obtained the requirements of the Colombo market would have to be considered and the general policy in regard to manufacture would come up for consideration. Meantime work would be carried out to see how far similar results could be obtained with conventional rollers.

In reply to Mr. Bois, the *Director* said the two experimental invoices, Normal and Clivemeare recently sold were made on alternate days.

Mr. Cameron asked if it was now intended to send comparative invoices of Normal and Clivemeare tea. To this the *Chairman* replied this would cause undue delay owing to the smallness of St. Coombs crop. Prices could, however, be compared with those obtained by other estates in the District working on normal lines.

Mr. Hoare pointed out that it was uncertain what quantities of Clivemeare tea could be absorbed by the market. He assumed that the Institute in replying to inquiries as to Clivemeare manufacture would confine itself to giving details of the experimental result obtained and would not take the responsibility of advising estates as to the policy they should adopt in regard to the type of manufacture.

After further discussion the Board unanimously approved of the proposal that the next six breaks should be made by the Clivemeare process and sent for sale in London.

Green Manures and Shade.—Referring to the recommendation in regard to a greater use of Albizzia on St. Coombs, *Mr. Pyper* asked if Gliricidias could not

be grown. *Dr. Gadd* replied that the results with Gliricidia had been unsatisfactory, the elevation being probably too high. Albizzias on the other hand were doing very well.

The Board accepted the Visiting Agent's Report dated May 27, 1939, and the Minutes of the Meeting of the Estate and Experimental Sub-Committee held on July 8, 1939.

7. DISEASES AND PESTS

Tortrix.—Reported that the regulations in regard to Tortrix made under the Plant Pest Ordinance have been suspended as requested by the Institute. The Chairman thanked the Director of Agriculture for his assistance in this matter.

8. T. R. I. CONFERENCES

The Chairman said the Minutes of the last Board Meeting containing full details of the discussion on the suggested Liaison Committee, &c. had been sent to the Planters' Association of Ceylon and to all District Planters' Associations. The subject has been discussed by two or three districts.

The Planters' Association of Ceylon was in favour of the formation of such a Committee.

Nuwara Eliya District Planters' Association had already nominated two Members to serve on the Committee if formed.

Other District Planters' Associations had apparently not discussed this aspect of the question.

Kandy District Planters' Association favoured sectional conferences with adjacent districts, *e.g.*, a Conference at Kandy for Kandy, Matale and Madulkelle planters.

Madulkelle suggested that intimation of staff visits should be sent to District Planters' Associations to enable other Superintendents to meet the officer in question.

The Board has instructed the Director and himself to put up concrete proposals and, after discussion of the matter, the following scheme was suggested, for consideration :—

(*a*) A Committee be formed consisting of—

(1) 2 Representatives of the Planters' Association of Ceylon.

(2) 2 Representatives of the Ceylon Estates Proprietary Association.

(3) 2 Representatives of the Low-Country Products Association.

(4) 2 Representatives of each District Planters' Association interested in tea.

(5) Ten General representatives, nominated by the Director to include Visiting Agents, Proprietors and unorganized interests.

(*b*) This Committee to meet at St. Coombs, its function being to keep all interests informed of the investigations in progress at St. Coombs and at the same time bring to the notice of the Institute any problems of special interest to particular districts.

(*c*) In future *two* Visitors' Days per month to be arranged, namely the *second* and *last* Wednesdays in the month.

It was suggested that the Committee would at most meet not more than twice in the year, once in a Conference year, unless some urgent matter of general interest required to be discussed.

If the above suggestion were adopted general Conferences on the present lines would continue to take place each second year.

The Chairman said that he and the Director hoped while in Assam later this year to examine the working of a somewhat similar Committee which exists there and they might therefore have further proposals to make on their return.

Mr. Pyper thought discussions might be deferred until after the Chairman and Director had paid their visit to Assam.

The Chairman suggested that if these proposals were approved by the Board, they might be sent now to the Planters' Association of Ceylon and the Ceylon Estates Proprietary Association for consideration, in order to save time.

The Board approved the proposals and the Secretary was instructed to send these to the Planters' Association of Ceylon and the Ceylon Estates Proprietary Association for their consideration.

9. SENIOR SCIENTIFIC STAFF

Reported that Mr. Lamb rejoined for duty after home leave on July 1.

10. VISIT TO ASSAM BY THE CHAIRMAN AND DIRECTOR

The Chairman reported that the visit to Assam by himself and the Director would extend from October 1 to November 10, allowing about 4 weeks in N.E. India. They hoped to visit the Tocklai Laboratory and representative tea areas.

Votes for the visit had already been approved in the estimates for the year and the Chairman said his Directors had agreed that he should accompany the Director.

11. RESEARCH ON THE CHEMISTRY OF TEA

Reported that Dr. A. E. Bradford had accepted the appointment of Research Chemist to the Joint Scheme. The Director had written to Dr. Lampitt to obtain further details of the programme of work.

12. ANY OTHER BUSINESS

(i.) Reported that His Excellency the Governor had visited the Institute on May 1.

(ii.) The Board approved the signing of the necessary agreement with the Postmaster-General in regard to the installation of the automatic telephone system.

The Meeting then concluded with a vote of thanks to the Chair.

ROLAND V. NORRIS,
Secretary.

July 17, 1939.

REVIEW

NUTRITION IN THE COLONIAL EMPIRE

A REVIEW OF THE FIRST REPORT OF THE COLONIAL OFFICE COMMITTEE UNDER THE CHAIRMANSHIP OF THE RT. HON. EARL DE LA WARR

THIS report consists of two parts published separately. In April, 1936, a circular Despatch was sent by the Secretary of State to all colonies requesting information in reference to nutrition, and part II. of the report is a summary of the replies received. Much of the information in part II. has been used in compiling part I. and therefore part II. may be considered first.

PART II.

The replies from the various colonies concerning the diets, state of nutrition, physique and economics appear in almost all cases to have been written from the impressions of doctors and others. Bold statements that the inhabitants of a country are of good or bad physique, that there is much or little poverty, and that deficiencies in the diets are prevalent or not, are of little value unless they are supported by the results of scientifically conducted surveys among the various classes of the population. And it appears that these have not been done, except in a very scanty manner, in any colony, except Ceylon, where several extensive surveys have been carried out. But it must be remembered that Ceylon is far more highly developed than many crown colonies, and such surveys would be far more difficult where the people are primitive and travelling facilities are not of the best.

The circular of the Secretary of State suggested the appointment of a committee in each country to study, and report upon nutrition, and to foster an interest in this very important matter. It appears from the replies that such committees have been formed in most countries.

The use of local names occurs in some of the reports; this is unfortunate in a publication which is intended for wide circulation. Words such as Fra-Fra potato, cocoyams, udalo, kumala, kawai convey little or nothing to readers in foreign countries. The term yam is used loosely for the tuberous roots of a large number of genera, and they differ considerably in their food values. It is hoped that the botanical name and the cultivated variety will always follow the appearance of a local name in future reports.

It appears from the reports that deficiencies of vitamin A and calcium which are marked among the poorer classes in Ceylon, are also of wide occurrence in other tropical lands.

PART I.

Part I., which runs to over 200 pages, is a discussion of the problem, and deserves a close study by all sections of the community, especially by those in charge of Government Departments.

Importance of the Problem.—A short introduction is followed by a statement of the importance of the problem. Although most of the Colonial Empire is within the tropics, yet there are outlying parts such as the Falkland Islands where the climate is subarctic, and consequently the committtee had to study a great variety of conditions which they have found " fascinating but bewildering ". In many places the necessary knowledge is completely lacking or very meagre. And although in some countries, such as Ceylon, the composition and values of the commoner foodstuffs are now known, there are many countries in which very little is known ; one example is East Africa where " several hundred different kinds of wild green leafy vegetables are used as relishes or side dishes " ; and very extreme examples are the use of grubs, wood lice, caterpillars, locusts, flying ants which are " largely eaten in tropical Africa".

The problem is far more than a question of eradicating deficiency diseases such as beri-beri, pellagra, kerato-malacia causing blindness, and others, although this in itself is an important field of work. " More important than the effect of malnutrition in directly producing disease is its effect in producing general ill-health and lowered resistance to other diseases, inefficiency of labour in industry and agriculture, maternal and infantile mortality and a general lack of well being".

One of the striking results brought out by the inquiry, was the almost complete absence from tropical diets of milk, and in many lands of all animal products. It has been customary in Europe to urge the increased consumption of milk, and to consider that some milk is essential for good nutrition in all diets. The committee recognized that in many countries it is impossible at present to supply milk and animal products in anything like the quantities which are normally regarded as adequate in European conditions.

The principles of correct nutrition in the light of the knowledge of to-day are summarized in chapter III. The untoward results of certain dietaries are not always due to deficiencies, but in rarer cases may be due to various poisons such as cyanides developing in foodstuffs, fluorides occurring in vegetable products as a result of their existence in unusual amounts in the soil, and various poisons being produced in grains or roots, during storage.

It will certainly be necessary for many of the vegetable foods of Ceylon to be analysed for cyanides and fluorides. The latter cause mottling and decay of teeth, and it is possible that this may be one of the causes for the prevalence of dental caries in Ceylon.

The General Character of Colonial Dietaries.—These dietaries, with few exceptions, are mainly vegetarian in nature, and in comparison with European standards relatively small quantities of animal products are consumed, and by the same standards they lack variety and protective value.

Effects of Malnutrition in the Colonial Empire.—Although marked deficiency diseases, such as beri-beri, scurvy or rickets, may not be prevalent, the less marked effects of various deficiencies such as nightblindness, xerophthalmia, Bitot's spots, dry skin, and phrynoderma may be very widespread. And where this is the case it is certain that there will be stunting of the growth of many children of the poorer classes, an increased susceptibility to infections, and a general impairment of health.

The General Character of Problem.—The report states " The main causes of malnutrition in the Colonial Empire are, in our view ; first that the standard of living is often too low ; secondly, that there exists great ignorance coupled with prejudice both with regard to the diet itself and to the use of land. We should add also, as a third main cause, the influence of other diseases which react upon the state of nutrition of the individual. This is particularly true of the various types of parasitic infestations which are widespread amongst the inhabitants of tropical countries".

There is a vicious cycle in that malnutrition effects efficiency, and this lowers the workers' value, and produces a low economic status, and this maintains the prevalence of malnutrition.

Agriculture and Nutrition.—The first two paragraphs under this heading in the report are :—" The nutritional problem being largely an agricultural problem, it follows that in framing agricultural policy the nutritional needs of the community are of first importance. In ascertaining what these requirements are, those responsible for agricultural policy will need assistance from the health authorities. It is for the health authorities to say what are the main deficiencies of the diet of a particular territory and for the agricultural authorities to consider how the deficiencies may best be met.

There is therefore need for very close co-operation between the two departments. Indeed there is really need for something more than co-operation. The knowledge of the doctor is apt to stop short at the analysis of deficiencies and that of the agriculturist to begin with the science of growing crops. Neither has the full knowledge to enable him to say authoritatively which foodstuffs are best able to remedy which deficiencies. For this purpose, if the co-operation between the two departments is to be really fruitful the Medical Department must know something of the agricultural possibilities and limitations and the Agricultural Departments something of nutritive requirements".

This is sound advice to the two departments. The medical authority will know of vegetable products which would be useful for correcting nutritional deficiencies but might be quite ignorant of the possibilities of producing them in any particular climate, rainfall, and the soils available ; and on the other hand although the agricultural authority may know the chemical composition of various foodstuffs, he will be ignorant of digestive utilization and other important factors ; for instance although a vegetable product may be rich in calcium or iron it does not necessarily follow that either mineral is in a form in which it can be properly absorbed and utilized by the body.

Desirable Additions to Colonial Diets.—To increase the quantity and variety of foodstuffs the introduction of new crops is urged. The roots grown in Ceylon

such as the yams, and sweet potatoes are very poor types and do not compare favourably with similar roots grown in the West Indies, and some parts of Africa, or with the various taros of the islands of the Pacific. The introduction into Ceylon of the best varieties of other countries would be a valuable supplement to the local dietaries.

The importance of animal husbandry is urged not only for the production of milk and meat, but also for the maintenance of soil fertility.

Nutrition of Paid Labourers.—" It has long been realized that poor feeding is one of the chief causes of high mortality and morbidity and low efficiency in labour in the tropics ".

Much valuable evidence on this subject has come from Africa. There is a very sad tale to tell of the sickness rate, mortality and general inefficiency a few years ago among labourers working on railways, roads, in mines and on estates in many parts of Africa. That most of this was due to malnutrition, is now recognized by Governments and many employers. Several instances of increased efficiency in labour forces following the giving of proper diets are recorded in the report.

Following an improvement in the diets of labourers of the Union Miniere properties in the Katanga the mortality rate between 1926 and 1932 fell progressively from 53 per thousand to 8 per thousand.

The central Mining-Rand Group of South Africa employs 300,000 labourers a year, and it has been found that supplying these labourers with cooked meals of maize and wheat flour, beans, meat, nuts, and fresh vegetable of a caloric value of 4,400 is a business proposition.

" In Northern Rhodesia an elaborate minimum scale of food is now laid down by Government for labour working in the mines."

The Rhokana Corporation improved the diets of their 6,000 employees at a cost of £7,500 a year. The manager of the mine wrote : " If an increased efficiency of as little as 5 per cent. could be guaranteed by the balanced dietary advocated, it would be a sound economic proposition".

The Government of Uganda has recently provided a well-balanced diet for the labourers employed on road construction. " This has resulted in a very much lower incidence of sickness than is usual in such constructional work".

The report states :—" We regard it as almost certain that in Africa, quite apart from humanitarian considerations, any money spent on bringing the food consumed by the labourer up to an adequate well-balanced ration will be money well spent from the immediate point of view of an employer ".

" Nevertheless, the tradition that a labourer can do all that is required of him on rations of cereals and little or nothing else is slow in dying.......... It cannot be sufficiently emphasised that while a diet of little or nothing but cereals may keep body and soul together, it cannot suffice for full efficiency."

The report recognizes that all Governments are the employers of much labour and states :—" The recommendations which we make are much less likely to commend themselves to private employers if the Government which puts them forward is itself liable to the retort " Practise what you preach".

The Factor of Ignorance and the Need for Education and Propaganda.—Under this heading the authors recognize that ignorance is not confined to the lower classes. "The study of nutrition is such a new science that its conclusions may not always be generally understood amongst those who have an influence on the nutrition of others, such as government officials, members of legislative councils, employers of labour, education authorities and missionaries".

"Some instruction in human nutrition in colonial conditions should be given not only to medical and health officers but also to administrative cadets during their courses at Oxford and Cambridge; to agricultural and veterinary officers ....to all education officers and teachers both in Government and Mission schools."

Methods for educating the masses especially the school children are also dealt with.

The Need for Co-operation between Government Departments and for the Interchange of Information.—"A general and substantial improvement in nutrition in the Colonial Empire must depend upon the steady and concerted efforts over a period of years of many Government Departments and voluntary agencies. The primary responsibility necessarily rests with the Medical and Health Departments, but it is through the efforts of the Agricultural Department, working in conjunction with the Veterinary Department, that changes and adjustments in the production of foodstuffs must be made. Much can be done also by the Department of Education in contributing to an improvement in nutritional conditions. The efforts of the more specialised departments will not achieve their full effect unless they receive the support and co-operation of the administration. Of equal importance is the need for securing co-ordination". The establishment of nutrition committees and the need for further knowledge of conditions in all countries is strongly urged.

Nutritional Surveys.—The committee recognizing the great importance of acquiring further knowledge appointed a Research Sub-Committee. "In accordance with the conclusions of their report the Colonial Development Advisory Committee recommended that a sum of £24,000 should be earmarked as a token figure from the Colonial Development Fund for the purpose of providing for the next five years assistance to Colonial Governments to enable them to carry out surveys".

Under this scheme Dr. B. S. Platt and several scientific assistants are already at work in Nyasaland.

The Committee on Nutrition in the Colonial Empire.—It will not be out of place in this review to consider the constitution of the Committee which prepared this report, because it shows the wide nature of the authority of the report, and the many fields of knowledge on which the subject of nutrition impinges.

The Chairman, The Rt. Hon. Earl De La Warr, is the President of the Board of Education. Sir Edward Mellanby, Secretary to the Medical Research Council (well known for his work on rickets), Sir John Orr, Director of the

Rowett Institute for Nutritional Research, and Professor E. P. Cathcart, Regius Professor of Physiology in the University of Glasgow, represent the scientific medical aspect of nutrition.

Sir Frank Stockdale, Agricultural Adviser to the Secretary of State for the Colonies, represents agriculture.

The two experts on economics are Professor N. F. Hall and Mr. Francis Hemming. Anthropology and biology are represented by Dr. Raymond Firth and Dr. P. C. Esdaile respectively.

Mr. H. S. Scott, late Director of Education in Kenya and Mr. Hanns Vischer, Secretary to the Colonial Office Advisory Committee on Education, are the protagonists for their aspect of the subject.

Administration has representatives in Mr. G. L. M. Clauson, Assistant Secretary to the Colonial Office, and Mr. E. M. H. Lloyd, Assistant Director of the Food Department of the Board of Trade.

And the direct public health aspect was represented by Dr. J. M. Hamill, Senior Medical Officer, Ministry of Health, and Dr. A. J. R. O'Brien, Chief Medical Adviser to the Secretary of State for the Colonies.

This galaxy of talent in many walks of life should bring ample conviction that the report will be worthy of study not only in all Government Departments but by the public. Furthermore the recommendations they put forth should receive the closest attention of Government.

It might be suggested that only one or two of the committee have had experience in the tropics ; but their duties have been to co-ordinate reports from the tropics and to stimulate interest in the matter, and they have been careful to abide by general principles and have avoided dogmatism as to what can or cannot be done under local conditions.

As this is called the " First Report ", presumably the committee has no intention of relinquishing its efforts, and we may look forward to further reports.

LUCIUS NICHOLLS.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED JULY 31, 1939

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1939	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Blackquartor	1	..	1	..	..	..
	Piroplasmosis	4	1	..	3	1	..
	Rabies	2	..	..	..	..	2
	Rinderpest	9	..	..	2	..	7
	Haemorrhagic Septicaemia	3	..	3	..	..	..
Colombo Municipality	Foot-and-mouth disease	32	5	2	29	..	1
	Anthrax	1	..	1	..	..	..
	Rabies	2	..	2	..	..	..
	Piroplasmosis	5	..	..	5	..	..
Cattle Quarantine Station	Foot-and-mouth disease	2	..	..	2	..	..
	Anthrax	29	..	29	..	..	..
Central	Foot-and-mouth disease	174	37	..	137	37	..
	Anthrax	5	2	5	..	..	..
	Rabies	8	..	2	..	..	6
	Piroplasmosis	9	..	1	8	..	..
	Contagious mange	18	..	2	16	..	..
	Blackquarter	8	..	8	..	..	..
Southern	Foot-and-mouth disease	595	530	31	488	76	..
	Rabies	1	..	..	..	..	1
	Haemorrhagic Septicaemia	4	..	4	..	..	..
Northern	Foot-and-mouth disease	130	..	7	123	..	..
Eastern	Foot-and-mouth disease	5	..	..	5	..	..
North-Western	Foot-and-mouth disease	122	..	3	119	..	..
	Rabies	4	1	1	..	..	3
North-Central	Foot-and-mouth disease	1,666	..	10	1,351	305	..
Uva	Foot-and-mouth disease	101	..	4	90	7	..
Sabaragamuwa	Haemorrhagic Septicaemia	1	..	1	..	..	..

Department of Agriculture,
Peradeniya, August 18, 1939.

M. CRAWFORD,
Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, JULY, 1939

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	DAY	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	84·2	—0·4	76·1	—1·0	80	88	7·6	8·62	20	+ 2·66
Puttalam ..	86·0	+0·3	78·1	0	75	84	6·4	0·84	4	— 0·52
Mannar ..	86·7	—1·2	79·3	+0·2	75	85	8·8	0	0	— 0·51
Jaffna ..	86·0	0	80·3	+0·8	77	78	5·0	0	0	— 0·56
Trincomalee ..	93·2	+1·0	78·6	+0·8	54	78	6·4	0·10	1	— 1·77
Batticaloa ..	93·9	+1·6	76·8	0	56	75	4·7	0·14	2	— 1·03
Hambantota ..	86·5	—1·5	76·3	+0·2	76	88	5·7	1·66	9	— 0·77
Galle ..	82·3	—0·4	76·5	—0·2	82	86	6·8	4·29	20	— 2·41
Ratnapura ..	85·8	—0·7	73·9	—0·5	77	93	6·8	15·14	23	+ 1·80
Anuradhapura ..	89·5	—1·4	75·0	—0·7	64	90	6·9	0·19	2	— 1·17
Kurunegala ..	85·3	—1·3	74·5	—0·6	75	88	6·5	7·18	20	+ 3·06
Kandy ..	81·9	—0·6	69·6	—1·1	76	79	8·2	8·09	20	+ 0·47
Badulla ..	86·4	+0·1	63·5	—0·5	54	89	4·6	0·27	4	— 2·12
Diyatalawa ..	77·4	—0·8	62·1	—0·4	58	73	5·8	0·65	10	— 1·31
Hakgala ..	67·2	—1·0	56·1	—1·3	82	88	5·8	5·37	15	— 1·96
Nuwara Eliya ..	64·0	—1·6	54·6	—0·1	85	91	9·0	9·39	23	— 2·44

The rainfall for July was below normal over the greater part of the Island, the larger deficits being more or less confined to the Southern Province and the hill-country. Appreciable excesses were recorded at a few stations on the western slopes of the central hills, and in the Colombo and Kurunegala Districts. The greatest excesses reported were 8·31 inches, at Kabaragalla, 7·30 inches, at Luccombe, and 6·77 inches, at Helboda, while the greatest deficits were 5·89 inches, at Morawaka, and 5·17 inches at Anningkanda.

The highest monthly totals reported were 32·19 inches, at Norton Bridge, 31·60 inches at Luccombe, and 30·30 inches at Watawala, while totals of over 25 inches were also reported from Padupola, Blackwater and Abergeldie.

More than 75 stations, the majority of these in the North and East of the Island, reported no rain at all during the month.

No daily falls of 5 inches or over were reported during the month.

The weather continued to be of the usual south-west monsoon type throughout the month, with south-westerly barometric gradients, winds generally south-westerly, and rainfall mainly confined to the south-western low-country and the hills. The rainfall was appreciably heavy on the 2nd, 3rd, 13th and 16th-18th, while little or no rain fell on the 8th 10th, 20th--22nd, and the 31st.

Temperatures were, on the whole, slightly below normal, except on the east coast. Humidity and cloud were generally below normal. Winds at the coast were, on the whole, south-westerly and above average strength.

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EDITORIAL

PADDY FARMING AS A CAREER FOR THE SMALL CAPITALIST.

THE last number of this journal contained a note on a year's cropping of the paddy seed station at Anuradhapura. This number has a similar note in respect of the paddy seed station at Paranthan. The information that these notes give would at any time be very valuable to agriculturists of this country. At the present moment when the importance of the increase of local food production is recognized by the people, this information has an immediate practical value. We therefore make no apology for drawing the attention of our readers to the two notes.

Full cost accounts began to be kept in departmental seed paddy stations two years ago, and agricultural officers are now in a position to supply authentic and reliable information with regard to the average yields and the cost of production of paddy in the Island—subjects on which inaccurate and unproved statements are often made by enthusiasts with an air of authority. The Anuradhapura station is irrigated from the Nuwara Wewa, is representative of the average paddy soils in the area, and is very unfavourably situated with regard to the supply of water when the level of the tank is low. The Paranthan fields are below the average with regard to soils under the Iranamadu Tank, but are favourably situated with regard to irrigation. The only agricultural practices not available to the small peasant that were adopted at the two stations were the application of fertilizers and the use of a good mould board plough : but they are not beyond the capacity of the small capitalist, and the figures may be studied in relation to the problem of finding agricultural careers for the class of youth for whom the parents can provide about Rs. 2,000 of capital and 75 acres of ready-made paddy land. It should be noted that in the accounts now presented to the public no mention is made of interest on the capital outlay which may be as much as Rs. 400 per acre.

At Anuradhapura the same fields are cultivated in both seasons of the year. The total annual yield of paddy in the station of 36 acres in extent was 2,537 bushels—which gives an average of 70 bushels per acre; cost of production was Re. 1·37 per bushel. At Paranthan a total area of 75 acres was cultivated with paddy during the year—20 acres being put under the crop in both the seasons. From the 75 acres a total yield of 3,894 bushels of paddy was obtained—an average of 52 bushels per acre. The average cost of production in this case was Re. 1·50 per bushel.

If the area of 75 acres were worked by a small capitalist farmer in the same manner as it was worked by the Department, in examining its value to him the Rs. 610 which represented the salary of the conductor may be placed on the side of his income. The sum of Rs. 1,000 obtained by the sale of straw should be left out of consideration because straw is not saleable in all parts of the country. If the capital expenditure on the field is taken to be Rs. 400 per acre and interest is secured on that capital at 5 per cent., the cost of production rises by 40 cents to Re. 1·90 per bushel. Therefore a proprietary farmer who invests Rs. 30,000 in acquiring a paddy farm of 75 acres and has working capital of two to three thousand rupees, can get 5 per cent. per annum on his capital and an income of Rs. 1,800 a year as return for his enterprise if he can sell his paddy at Rs. 2·25 a bushel ex farm. It is believed that if the price is stabilized at Rs. 2·50 a bushel, assuring an income of Rs. 3,000 a year, there will be a general desire to take up paddy cultivation. So long as the price of paddy remains below Re. 1·90 per bushel, the farmer who works with paid labour will incur an annual loss.

Perhaps paddy farming can be made to yield a reasonable income at a lower level of paddy prices for a number of years if the whole of the 75-acre farm is put under paddy in both the seasons—but the practice will lead to the rapid deterioration of the soil and it is not recommended.

PREPARATION OF LANDS UNDER MAJOR IRRIGATION WORKS FOR PADDY CULTIVATION

R. KAHAWITA,
IRRIGATION ENGINEER, IRRIGATION DEPARTMENT

THERE are several Government-subsidized colonization schemes scattered in different parts of the Island wherever there are large irrigation schemes. Colonists who are settled under them are drawn from a semi-agricultural class seldom accustomed to irrigation from a system built on highly scientific lines. On account of their inexperience the advantages of such a system are lost to them and often they feel, when they encounter difficulties, that the system is defective. Also, owing to their wrong methods of irrigation there is an excessive waste of water which we can ill afford in a country where incidence of droughts seems to follow a 5-year cycle.

Before a colonist is settled on the land, it is usual for the Government to clear the jungle for him. Then the colonist is expected to asweddumize the land and start cultivation under the supervision of cultivation officers or colonization officers. We realize that very valuable help can be given to the cultivators at this stage if they are properly advised on the field itself on the best method of preparing the land to suit the configuration of land and the irrigation system already constructed. The following notes are mainly meant to guide those whose duty it is to advise and help colonists in the preparation of their lands.

To save water in the irrigation of paddy, the best soils are those which are nearly, if not entirely, impervious. An impervious top soil or a pervious top soil with an impervious sub-soil at a depth of about 2 feet can be considered to answer the requirements for economic irrigation.

Once the jungle has been cleared, lands could be prepared for cultivation. It would not be necessary to remove stumps except those that may come in the line of the ridges. In the early stages of the development it will be very uneconomic to undertake the removal of large stumps. Stumps up to 28 inches in diameter can be removed by manual labour at an economic rate

in the course of asweddumizing. The depth to which the soil should be free from stumps and roots is about 12 inches. This will allow ploughing even with a heavy, improved type of plough. It is best to leave the removal of large stumps to the second year of cultivation. By then the stumps would be sufficiently dry and decayed to burn. For burning, a method explained in a previous article published in 1938 (*The Tropical Agriculturist November, 1938*) may be employed with advantage.

The class of colonist that is available for settlement under irrigation schemes has no financial resources to develop the land. His capital is his capacity for work and even this is limited owing to his poor physical condition. His labour when capitalized under the prevailing conditions will average to about 60 cents a day of 10 working hours. His physical condition also limits the initial outlay of work in preparing the land to a minimum compatible with his primitive methods of agriculture. To get the best advantage of a modern irrigation system and to harvest a maximum crop with the minimum consumption of water, a good deal of levelling and preliminary work on the land is required. This cannot be expected of the local peasant. Nor is he, even if it be done for him, in a position to pay its cost. For instance, in America where things are done on a "grand scale"—land-levelling and other preparatory work are undertaken by contractors who maintain all the necessary machinery and implements for this type of work. A great deal of attention has been paid to land preparation in that country for two reasons: (*a*) economy of irrigation water as every scheme is commercialized and every cubic foot of water delivered to the land must be paid for, (*b*) high yield on well-prepared soils that have been lying fallow for centuries. "Bumper crops" during the first few years more than compensate for the initial outlay on proper land preparation. We may not be able to follow this great country, but if we are keen on seeing the dry zone populated with healthy and efficient peasants, the importance of the economic use of irrigation water cannot be over emphasized. Agricultural possibilities are immense in the dry zone if a regular and unfailing supply of water is available.

The object of land levelling is to grade the land to take an application of water without undue waste and at the same time to bring under cultivation as large an area as possible with the head of water supplied from the channel system. Reasons for some systematic method of preparing the fields are to secure an even distribution of water over the fields which would give a uniform growth to the crop, and to minimize the wastage of water from the fields. In poorly-prepared lands more labour and attention will be required from the cultivator to get a fair distribution of water over his land and, even with the extra

attention paid to his land, yield will be less owing to unequal growth. Labour involved in the preparation of fields can be greatly reduced by adopting the method of applying the water to suit the lay of the land.

In the dry zone, where most of the colonization schemes are situated, the ground surface is fairly flat except for isolated mounds—the work of active termites for several years—and gullies formed by erosion during heavy rains. Sometimes these anthills occur at close and regular intervals forming a miniature range of hills. Not taking into consideration such mounds and undulations, it is seldom that one gets an appreciable variation of levels in a 5-acre block—the unit of land given to each colonist. On account of the nature of the soil formations that occur in the dry zone, no levelling should be carried to a depth of more than 12″. Below this, variations of soil may occur giving a spotted yield with different water requirements.

The usual practice is to lay down the main supply system based on a topographical survey of the area long before the land is opened up and, when the land is opened up, to lay down the field system to suit the individual blocks. Before this is actually planned out on the field it is necessary to get an idea of the contours from a contour plan. Such a study will help to choose the method of applying the water to the fields and at the same time to save a good deal of erratic ridging that may be done by a cultivator who fails to pay heed to the topography of his field. In all cases ridging must precede levelling. For, if this is done, water could be admitted to the fields and the extent of levelling required determined. After all, a cultivator will be required to asweddumize his field only once and the benefits of the extra labour involved in efficient asweddumization will be reaped ever after. The better the execution of this first operation, the less will be the time spent in subsequent operations. In well-prepared fields, levels in a *liyadde* or check should not vary more than one to one and a half inches above or below a planned grade. Otherwise extremely high ridges will be required to avoid spotted growth.

Once the nature of the land is known—often it becomes obvious by a tour of observation of the area—the method of applying the water to it can be decided upon. Three methods are available in the irrigation of paddy fields. The first of these is called "strip checks" or *liyaddes*. In this method a sheet of flowing water is confined between two ridges extending lengthwise down the natural slope. Water is taken from a channel at the upper end of the block. Block No. 82 in Plate I. illustrates this method applied to a 5-acre block in the Minneriya Scheme. All the necessary details are given on the plate. It is customary to run the strip checks parallel

to the sides of the block to secure uniform lengths and arrangements of checks and to avoid odd areas. In trying to adhere to this arrangement it may so happen that the ridges run at right angles to the contours so that the slope becomes too steep. In such cases the length of check may be broken up by cross ridges provided with overflow sections. Within the *liyaddes* the ground must be made level transversally so that water will flow over the whole width at an even depth. Slope in the direction of ridges may vary or be uniform. This is controlled by the cost of levelling. Of course an even grade is the ideal. The first 30 feet at the top of the check where the water is admitted must be made level so that the water spread may be distributed evenly across the entire width of the *liyadde* before flow starts down the slope. Earth obtained in levelling this section of check can be used to form the banks of the field channel. In Plate I. an exaggerated long section of a *liyadde* is shown to illustrate the adjustment of slopes without excessive levelling.

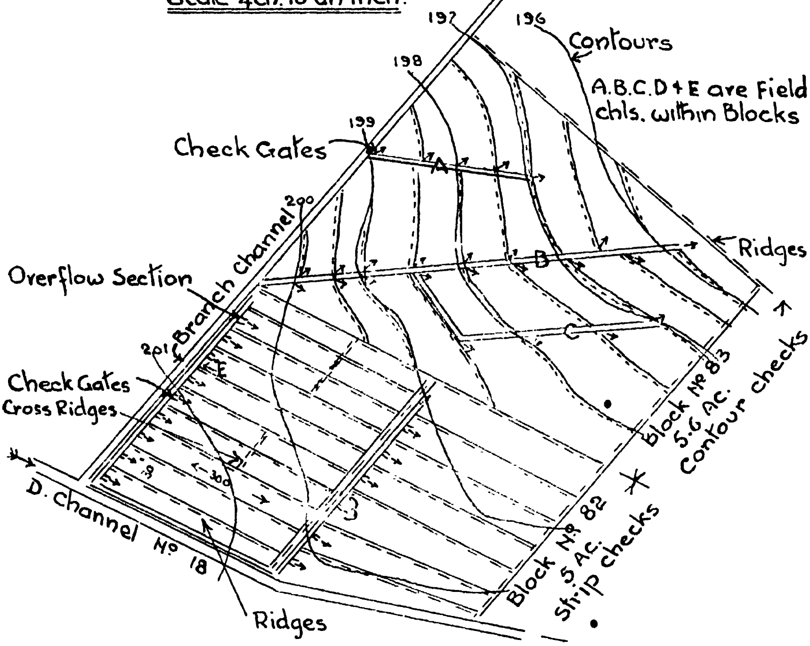
Economic slopes for strip checks vary from 2 to 6 inches per 100 feet. Slopes more flat than 2 inches reduce the length of check involving more field channels ; and there is no advantage in adopting this method on slopes steeper than 6 inches. It means very high and too many cross ridges. The lighter the soil texture the steeper should the slope be. This will keep the end of the check supplied with sufficient water. There is no definite rule to control the width of a *liyadde* but it should not be narrower than 30 feet in any case and, with small irrigating heads, it should not exceed 60 feet. Length is dependent on the slope, head of water, and the texture of the soil. For the type of soils suitable for paddy cultivation length may vary from 100 feet to 500 feet. Control of water, *i.e.*, duration of an issue, will be extremely difficult in *liyaddes* longer than this. For the information of those to whom it might be of interest, this phase of the problem is treated mathematically in Appendix I. of this arricle. As a guide, suitable dimensions of strip *liyaddes* are given in Table I.

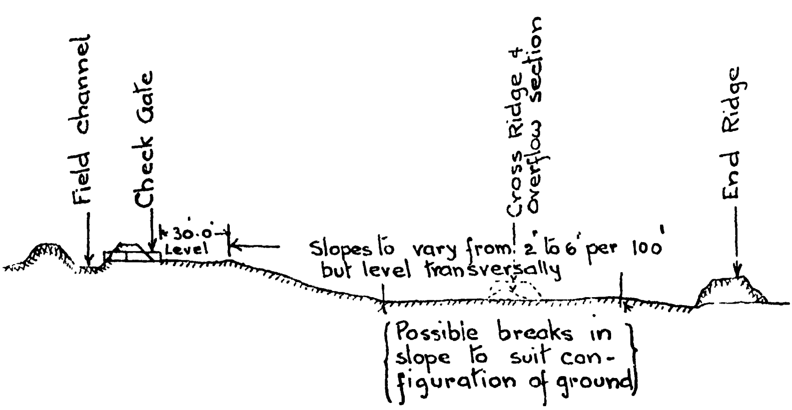
TABLE I.

Irrigating Head Cusecs	Soil Types: Heavy Medium		Soil Types: Heavy	
	Width	Length	Width	Length
1 cusec	30	100 to 150	30	150 to 200
1 to 2 cusecs	30 to 40	150 to 200	30 to 40	250 to 350
2 to 3 cusecs	30 to 40	200 to 300	30 to 40	350 to 500

These figures give a variation of head from 0·03 to 0·1 sec. feet per width of check and if a cultivator handles the smallest

PLATE I
TWO 5 AC. BLOCKS
SHOWING ADAPTATION
OF CONTOUR AND STRIP METHODS OF
IRRIGATION
Scale 4 ch. to an Inch.





AN EXAGGERATED SECTION THRO. STRIP LIYADDA

Contour plans of Minnerie Scheme.

BLOCK BY SURVEY DEPT. CEYLON.

head *i.e.*, 1 cusec, he will be able to get his requirement for a 5-acre block in about 12 hours and the time spent in attending to it is about 3 hours at each watering.

In any kind of irrigation, ridges must be well and substantially made so that the water let into a check may be controlled. If the ridges are properly made at the commencement very little attention will be required during the period the crop is in the field. In well-prepared lands the settled height of a ridge should not be less than 12″ with a minimum top width of 18″ and side slopes 1 in 1·5—*vide* details in Plate II. Cross ridges employed for the control of flow must be provided with overflow system. A wooden overflow section is illustrated in Plate V. By the adoption of such structure repair and attention to ridges will be practically nil. The cost of making one is about Rs. 5·60. If a cultivator can afford the extra labour, it is a good practice to make fairly wide ridges, say about 3 feet top width. The area of the ridges will not be lost to crop production as vegetables could be grown on them successfully and with very little extra attention. This will be a source of income to the owner besides providing him with food during the cultivation season.

The usual practice of cutting channel bunds to take water and of cutting ridges (called *wakkades*) to pass the water from *liyadde* to *liyadde* should be discouraged as it involves extra labour in the control and distribution of water. Also it results in excessive and careless waste. Use of portable structures made of wood should be encouraged. These can be removed from the fields when the cultivation is over and re-inserted when the next cultivation season begins. Outlets from channels, check gates or regulators, overflow sections, and falls in channels, can be made of wood by a cultivator with a little experience in the handling of a few carpenter's-tools. These structures, properly cared for, will last several years. The writer has tried several of them in Nachchaduwa and Kagama Schemes with very good results. Already they have lasted over two years with very little attention. Designs for some of these structures as used by him are given in Plates III. and IV ; Table 2 gives the approximate quantities of timber required for each.

TABLE 2

Approximate Timber Requirements for suggested Structures

1.	Wooden drops ..	32 sq. ft.
2.	Check Gates	15 sq. ft.
3.	Overflow sections ..	28 sq. ft.

It is not necessary to have a continuous flow of water down a strip ; once the required depth of water is admitted into the *liyadde* the supply may be cut off. It may be done even before

the water has reached the end of the *liyadde*. Such a practice will prevent any wastage which is very important in successful irrigation.

Later when the fields are ready to take a plough, the first plough-share should be transverse to the *liyadde* and the second along the strip. This will produce checks of uniform slopes after a few seasons.

Taking the 5-acre block No. 82 illustrated as a typical field where the strip method of irrigation can be adopted, the cost of preparing one acre is Rs. 145. This rate is calculated on a contract rate basis but where a cultivator himself prepares the field with no intent of gain but to get his field asweddumized, it will, expressing the labour spent in the various operations in terms of money at 60 cents per diem, cost him from Rs. 130 to Rs. 135 per acre. Expenditure is distributed as follows :

	Rs.	c.
(1) Jungle clearing (usual rate for dry zone jungle) ..	35	0
(2) Stumping (can be spread over 2 years) ..	30	0
(3) 60 cubes of earthwork in channels and ridges at Re. 1	60	0
(4) About 4 wooden structures at Rs. 5 ..	20	0
	145	0

Earth for the ridges should be obtained by cutting mounds and in levelling the *liyadde* in a transverse direction. In doing this the maximum carry is the width of the *liyadde*. Before taking earth, the top soil must be scraped and heaped separately to be spread over the surface after levelling as top soil is very rich in manure in newly opened up land.

Field channels within a block form an important feature in irrigation. Therefore as much care as is given to asweddumizing must be given to the construction of channels. As a guide, Table 3 gives channel data for 3 different sizes of field channels.

TABLE 3

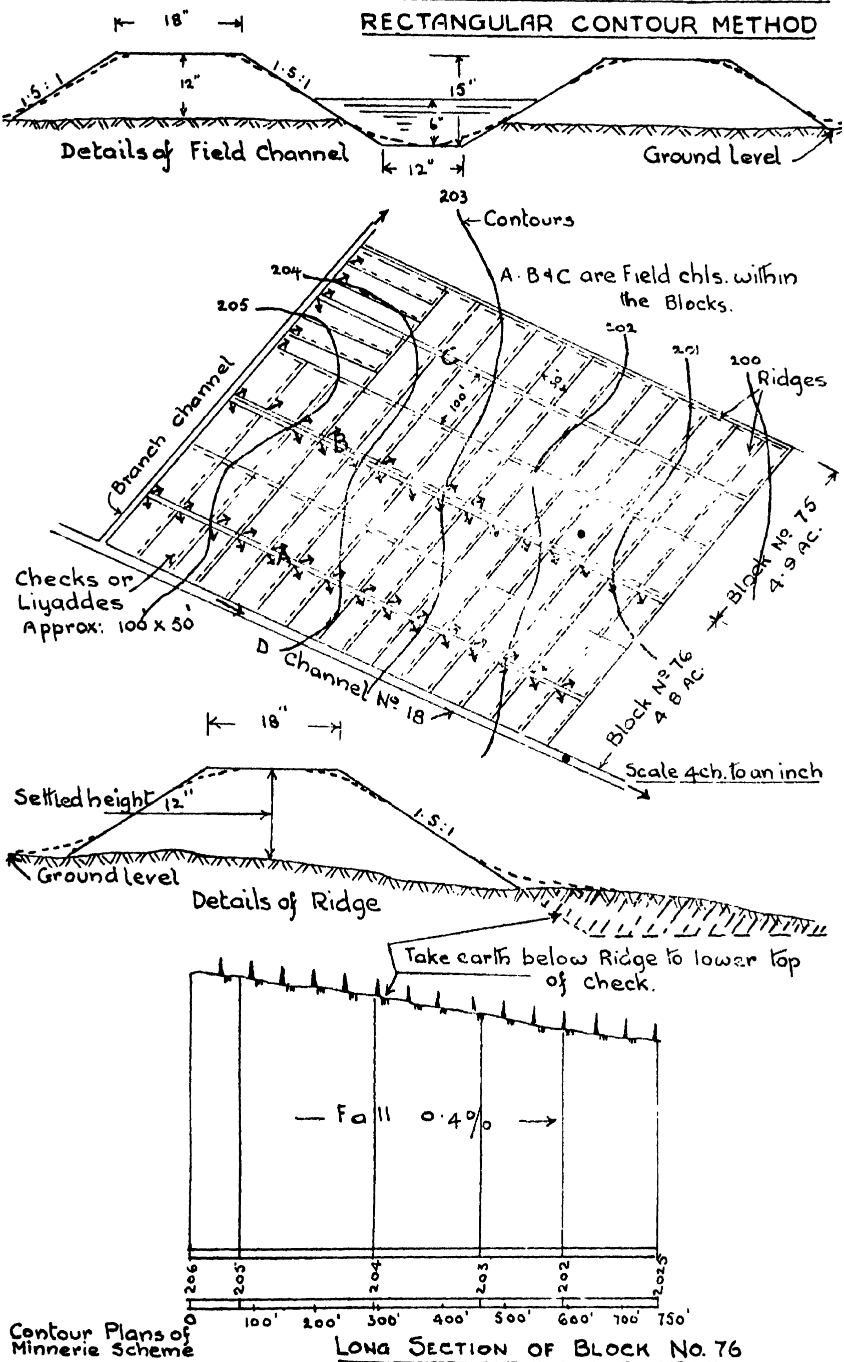
Carrying capacity of Field Channels

Bed width = 15″ Side slopes = 1·5 : 1.

Grade Per Cent.	Capacity in cusec					
	3″		6″		9″	
	V	Q	V	Q	V	Q
0·1	0·46	0·19	0·72	0·72	0·93	1·66
0·2	0·65	0·26	1·02	1·02	1·33	2·37
0·4	0·93	0·38	1·45	1·45	1·89	3·36
0·5	1·04	0·42	1·62	1·62	2·10	3·74
0·6	1·13	0·46	1·78	1·78	2·31	4·11

PLATE II

TWO BLOCKS SHOWING ADAPTATION OF RECTANGULAR CONTOUR METHOD



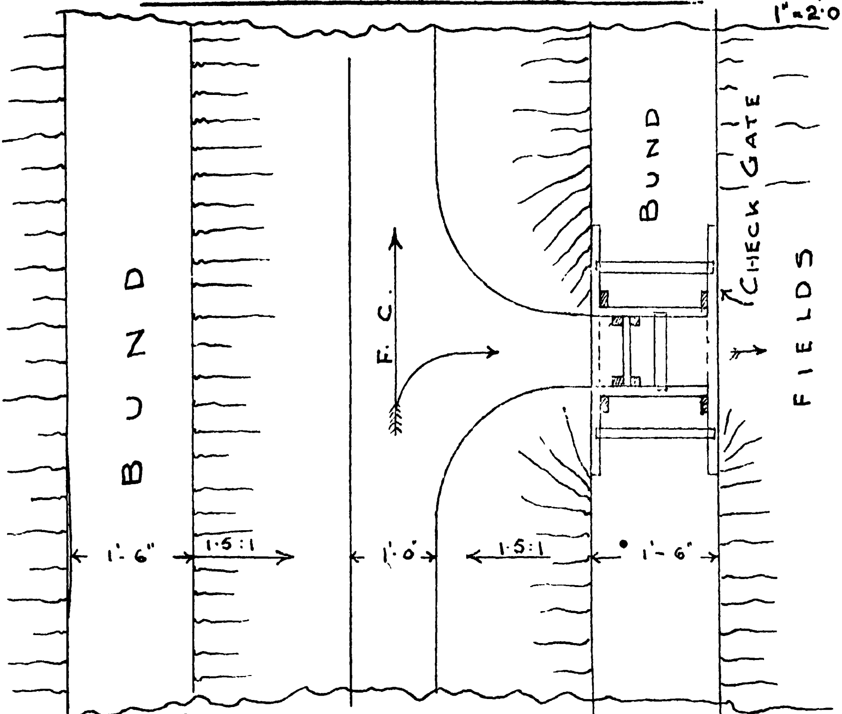
LONG SECTION OF BLOCK No. 76

BLOCK BY SURVEY DEPT CEYLON

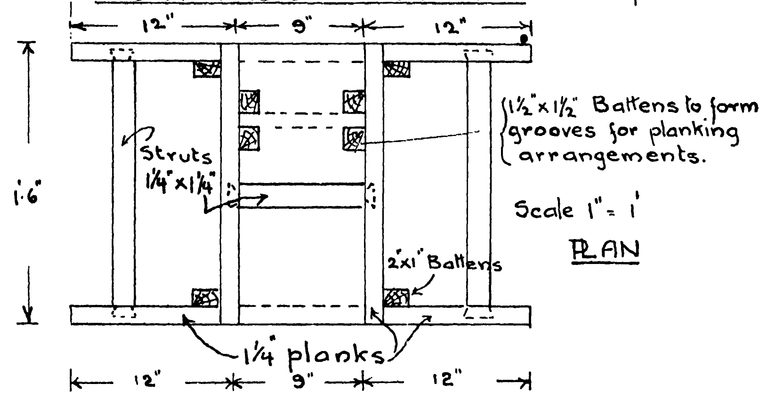
PLATE III

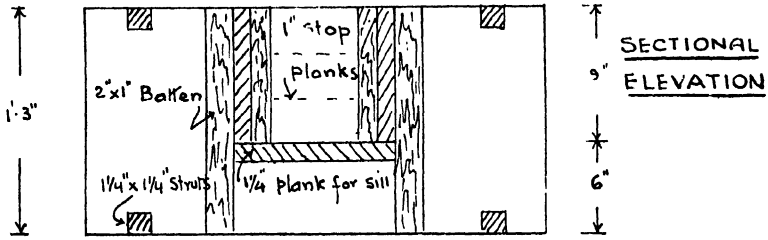
6"x9" WOODEN CHECK GATE OR REGULATOR

Scale 1" = 2'0"



FIELD ARRANGEMENT OF CHECK GATE





BLOCK BY SURVEY DEPT. CEYLON.

TABLE 3—*contd.*

Bed width = 18″. Side slopes = 1·5 : 1.

Grade Per Cent.	Capacity in cusec: 3″ V	3″ Q	6″ V	6″ Q	9″ V	9″ Q
0·1	0·47	0·22	0·80	0·96	0·97	1·91
0·2	0·67	0·32	1·13	1·36	1·37	2·72
0·4	0·95	0·45	1·60	1·92	1·95	3·84
0·5	1·06	0·50	1·79	2·15	2·18	4·28
0·6	1·17	0·55	1·96	2·35	2·39	4·70

Bed width = 24″. Side slopes = 1·5 : 1.

Grade Per Cent.	Capacity in cusec: 6″ V	6″ Q	9″ V	9″ Q	12″ V	12″ Q
0·05	0·58	0·84	0·71	1·66	0·85	2·98
0·1	0·82	1·19	1·00	2·35	1·20	4·20
0·2	1·16	1·69	1·42	3·32	1·70	5·94
0·4	1·65	2·39	2·01	4·71	2·41	8·43
0·6	2·03	2·94	2·48	5·80	2·94	10·30

A second method of irrigation is called rectangular and contour *liyaddes*. The principle underlying the two methods are the same. The difference, as the names indicate, is in the shape of the *liyaddes*. In this method water is admitted to, and ponded in, each check surrounded by well-formed ridges. Water is not allowed to flow from *liyadde* to *liyadde*. The head in each field is more or less self-adjusting to suit the head in the field channel. In-flow from channel to check will be just sufficient to compensate for losses. This system admits of easy control and reduces waste to a negligible quantity.

Rectangular checks are prepared at right angles to the sides of the block of land where the block itself is of the same shape. The ground within a rectangular check is made level or nearly level. From the arrangement of the checks it will be obvious that this method is well adapted to fields where the contours are at right angles to the sides of the field. It is illustrated in Plate II. where all the details are shown.

The width of a rectangular check is controlled by the rate at which the land slopes. This method could be adopted with general slopes of two-thirds of an inch to 4 inches per 100 feet. Then the maximum width of a check will not exceed 66 feet as the water has to flow to the farthest end of the field unaided by the fall of levels. Lengths should not exceed 300 feet. If the lands are fairly level, square checks of a maximum size of 200 feet square can be used. The longer the checks, the less will be the spacing of field channels within the block.

If the field channels are not carefully spaced, the advantages gained by adopting this method are lost. Field channels are run down the slope and the water is admitted directly into each *liyadde*, but in irregular areas, to save too many channels water may be admitted from one *liyadde* to the next through overflow sections (Plate V.) in the ridges. This should, at any event, be limited to two or three *liyaddes*.

The size and type of ridges are shown in Plate II. Earth for these should be taken from the upper end of the lower *liyadde* and never from the lower side of the upper *liyadde* unless there is a mound. Here the carry of earth will not be more than one third of the width of the *liyadde*. Structures required to distribute water and minimize field maintenance are the same as already described.

The cost of preparing an acre of land for this type of irrigation is about Rs. 150. In this method a quantity of about 20 cubes of earth more than that required in strip method is necessary in reducing grade.

In Plate I., Block No. 83 is arranged for contour checks. This method can be used for irregularly shaped blocks and where the contours are not regular. In both these methods if the ridges are fairly high and of substantial proportions fair differences of elevation within a *liyadde* may occur. When this method is applied to very steep land it becomes a form of terracing as done in the up-country rice fields. The maximum size of a contour *liyadde* should not be more than one fifth of an acre. Sizes larger than this require large heads and result in waste. In this method also water is delivered directly into each *liyadde*. One disadvantage of this method is the irregular shape of checks and the non-uniformity of the lay-out of the field channels.

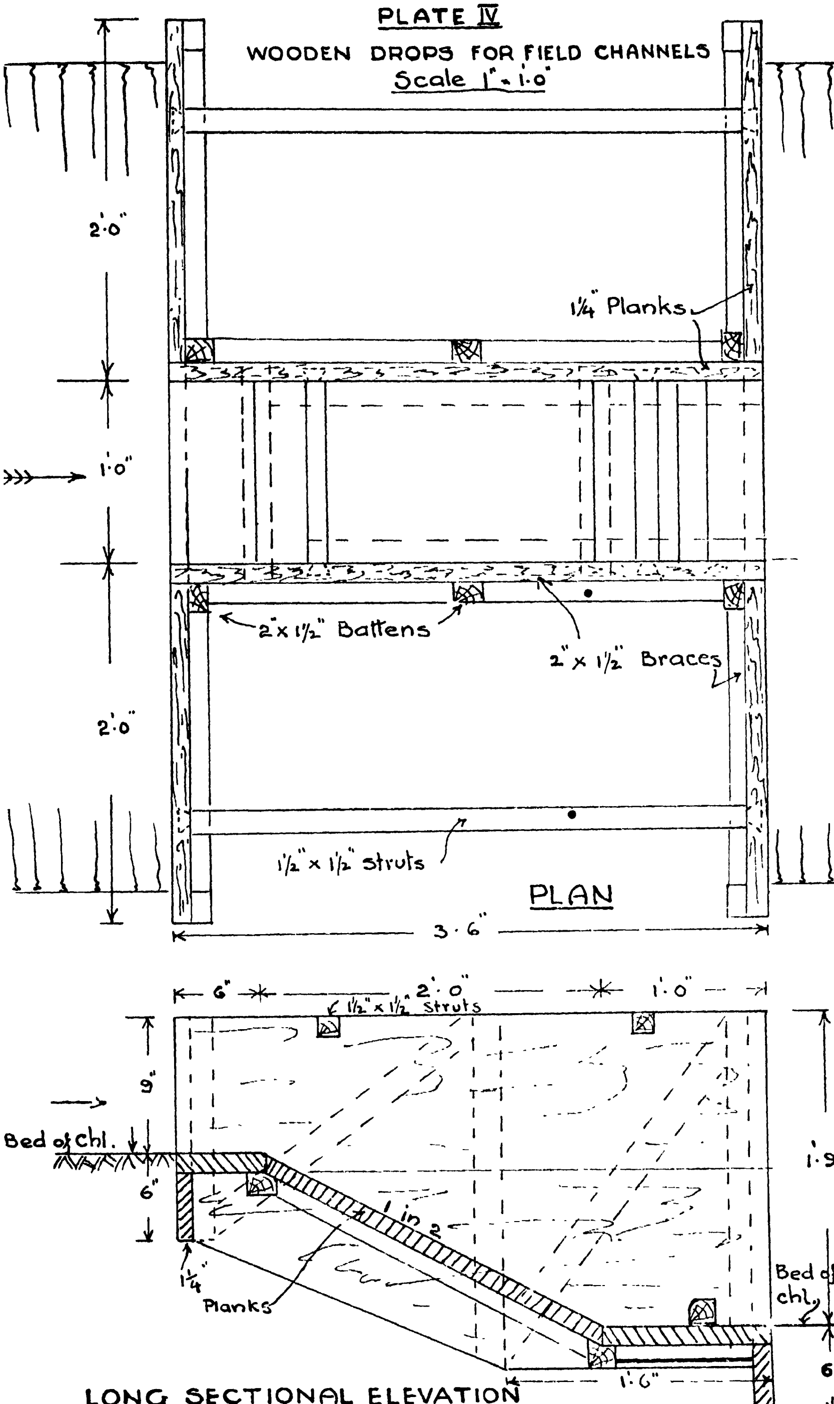
Ridges and field channels are similar to those used in the other methods except that the ridge along the contour includes the difference in elevation of the adjacent *liyadde*. Earth for the ridges is taken from the high side of the lower *liyadde*. According to the amount of levelling involved, ridges may be run at intervals of 4 inches to 6 inches difference of elevations. Here again water may be admitted from *liyadde* to *liyadde* through overflow sections in the ridges but the maximum run through the checks should not exceed 400 feet.

After the stumps have been removed and the fields are ready for ploughing, the first furrow must be with the contour and the second at right angles to it. And if mudding is done, floating after mudding should be done from the upper to the lower end. If the operations are adopted in this order fields will be rendered fairly level after about two seasons.

PLATE IV

WOODEN DROPS FOR FIELD CHANNELS

Scale 1" = 1'0"

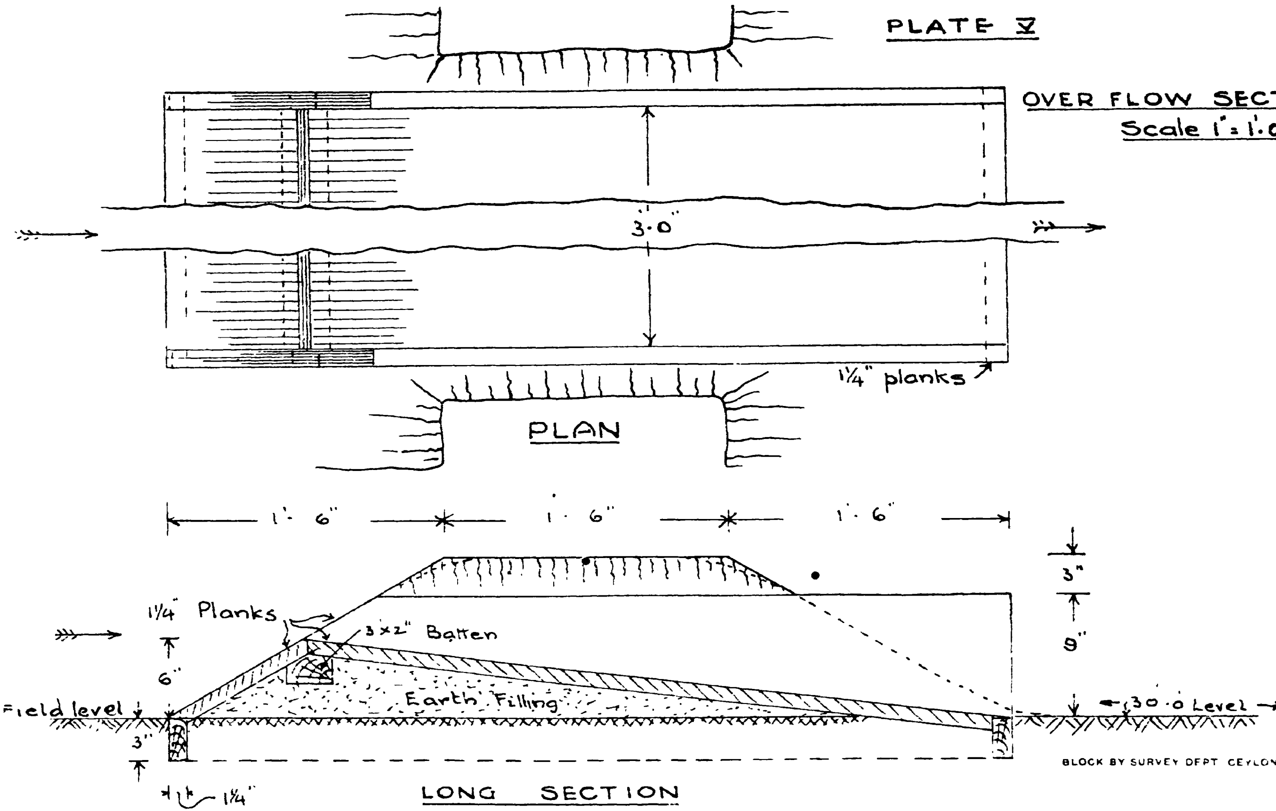


BLOCK BY SURVEY DEPT. CEYLON.

PLATE V

OVER FLOW SECTION

Scale 1" = 1'.0"



LONG SECTION

BLOCK BY SURVEY DEPT CEYLON

Cost of preparing lands for contour methods, including jungle clearing, stumping, &c., is about Rs. 150 per acre. Details of cost for lands in the Dry Zone are the same as for the strip method except for earth work which may be about 15 per cent. more or less according to the slope of the land.

APPENDIX I.

A Mathematical Analysis of Strip Irrigation

Same notations as were used in analysing flow of water in furrows discussed in an article published in *The Tropical Agriculturist* of November, 1938, are followed here. Let Q cusec be the amount of water flowing through the gate into each strip b feet wide. Then water flowing over unit width of strip will be $\frac{Q}{b}$ cusec. Let this be equal to q cusec. Let total time water is let into the strip be T seconds. This will be equal to t_1, time taken to reach end of strip and t_2 time the water allowed to flow after it has reached the end of strip. Then $T = t_1 + t_2$. Then total quantity of water flowing over a unit width of strip is qT cubic feet $=$ dl where d is depth of water over strip and l length of strip. Total quantity of water absorbed into the soil during time T is $d_1 = uT$. For meaning and values of u *vide* article referred to above. In time dt, q dt flows into the strip, when it has flooded a length x feet in time dt percolation is equal to u dt x and the amount flowing down is d_2 dx where d_2 is depth of water over strip after time dt. Hence we have the volumetric relation

$$q\,dt = u\,x\,dt + d_2\,dx$$

$$dt = \frac{d_2\,dx}{q-ux}$$

$$\text{then } t_1 = \int_{x=0}^{x=l} \frac{d_2\,dx}{q-ux}$$

Solution of this equation is

$$t_1 = \frac{d_2}{u} \log_e \frac{q}{q-ul}$$

From the relation $qT = dl$ we get

$$\frac{q}{q-ul} = \frac{d}{d-d_1} \qquad \text{Let } \frac{d}{d_1} = B$$

$$\text{Then } \frac{q}{q-ul} = \frac{B}{B-1}, \text{ then } t_1 = \frac{d_2}{u} \log_e \frac{B}{B-1} \text{ in terms of B}$$

B is the ratio of applied depth to depth absorbed into the soil so that minimum value of B will be unity. The following table gives the values of $\log_e \frac{B}{B-1}$ for values of B ranging from 1 to 5 :—

B	1	1·1	1·2	1·3	1·4	1·5	2	3	4	5
$\log_e \frac{B}{B-1}$	∞	2·4	1·8	1·5	1·2	1·1	0·7	0·4	0·29	0·22

If the ground within the strip is well prepared and levelled transversely as explained earlier, applied head of water may be very small, one-third of an inch to an inch. Otherwise it may have to be as much as 3 to 4 inches. In paddy cultivation it is the practice to pond 2″ to 3″ between two successive irrigations and in good paddy clay permeability u is very small—about 0·1 to 0·13 inches per hour. Hence percolation will be very little so that B will have a high value generally between 3 to 5 according to the applied head. t_2 is the time required to maintain flow to obtain a pondage of 2″ to 3″. Percolation during this time is $ut_2 = d_3$ where d_3 may include not only percolation but also evaporation and other losses.

$$\text{Then } T = t_1 + t_2 = \frac{d_2}{u} \log_e \frac{B}{B-1} + \frac{d_3}{u}$$

From this, duration of an issue to a strip can be found once the nature of the soil including subsoil and the required depth of pondage is known.

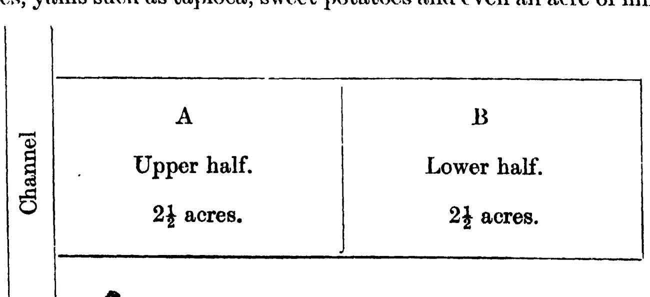
From $B = \dfrac{d}{d_1}$ it can be shown that $q = Blu$ for a unit width of strip 1 foot long per unit of time. Then if width of strip is b irrigating head $Q = blBu$ cubic feet per second per strip. This also expresses the duty of water in terms of soil conditions, *i.e.*, if Δ is duty of water in acres per cusec, then $\Delta = \dfrac{24.P}{43560\ Bu.T_1}$ acres per cusec where u expresses permeability, B a ratio of irrigating head to depth of percolation, T_1 duration of irrigation in hours and P interval between two successive irrigation in days.

APPENDIX II.

A Note on developing a 5-acre Block in the Dry Zone for Irrigated Crops

It is assumed that the jungle is cleared by Government before the peasant is introduced to the land, so that when he takes over the block he is expected to asweddumize the land by stages and complete development in three years.

Jungle must be cleared and burnt by end of July so that a peasant may take possession of a block in August. From August to October he should get the lower half of his block (B in sketch), about 2½ acres in extent, ready to put in a chena crop of millet, maize, varieties of pumpkins, mustard, a few varieties of vegetables, yams such as tapioca, sweet potatoes and even an acre of hill paddy.



In a normal year this operation will be over towards middle of October and the cultivator will await the N.-E. monsoons which generally starts early in October. When he has put in his chena crop he should commence to asweddumize the upper half of the block, *i.e.*, A in sketch, about 2½ acres in extent. If he does this systematically and on the principles explained in the main section

of this article he will have to do about 150 to 200 cubes of earthwork on the ridges and field channels within his block. According to the variety of paddy cultivated he will have from five to six months to get this area ready for a *yala* sowing, *i.e.*, during April–May of the following year he can put in an irrigated paddy crop. This will also allow him a month to gather his chena cultivation in about February–March and prepare the same half B to put in a gingelly crop in April if he desires so. After he has sown the upper half of his block with a three- or four-month *yala* paddy he will have about a month to wait to clear the gingelly crop, about June-July, if he has put in one. When he has cleared this he should start to asweddumize the lower half of the block. This type of work during June will not be difficult on account of the seepage, leaks, &c. from the fields above. The soil will be sufficiently damp for easy levelling and forming ridges. The amount of work involved will be the same and similar to that in the upper half. But he will not be able to get this ready for the coming *maha* sowing for he will have to harvest the *yala* crop in August–September. So, instead of starting a *maha* in the incomplete lower half, after gathering the *yala* crop he should prepare the same half A for a *maha* which should be over by the end of November for a four month paddy. Then from December to March he continues to asweddumize the lower half B. In March he will gather the *maha* crop in the upper half A and he will have the lower half B ready to put in a *yala* four month paddy in mid April. During this *yala* season he rests the upper half A but starts removing stumps. By this time the stumps would be sufficiently dry and rotted to be burnt or pulled out. Stumping of this area should be completed by the commencement of the following *maha*. After gathering in the *yala*, the whole of the block is prepared for *maha*. By this time he will have half of his block fully developed and the other half ready to be stumped. When he has gathered in a 5-acre *maha* crop in March, he prepares only the upper half A for *yala*. While the *yala* crop is ripening he should set to stump the lower half B and get it ready for cultivating during the following *maha* season. For this season he will have the full block developed and from thence onward he can follow the usual cultivation routine practised in the area.

To make it more clear a schedule of the various operations involved is given below in the sequence in which they should occur. This may be termed a colonist's programme of work in opening up his block.

First year :—

August-October. Prepare lower half B and put chena crop.
October-March. Asweddumize upper half A.
March-April. Gingelly in B after gathering chena crop.
April-May. Sow A for a 4-month paddy *yala*.
June-September. Asweddumize B after gathering gingelly ; also A to be harvested August-September.

Second year :—

October-November. Sow A with a 4-month paddy *maha*.
November-March. Continue to asweddumize B and complete it for *yala*.
March. Gather *maha* in A.
April-May. Sow B with a 4-month paddy *yala*.
May-September. Rest A but burn and remove stumps.

Third year :—

October-November. Sow A and B with a 4-month paddy *maha*.
November-March. No regular work in his block ; so he can attend to any non-irrigated crop if he has been given any land for this purpose. .Harvesting in March.

April-May. Rest B, and sow A with 4-month paddy *yala*.
May-September. Remove and burn stumps in B.
October-November. Sow full area A and B with a *maha* paddy.

Financial position.—As stated earlier it is assumed that the peasant has no jungle to be cleared on his land. The items of work he will be called up to perform on coming to the land are asweddumizing, stumping and cutting field channels. Also he will have to make or get made a certain number of wooden structures. In the above programme of work no consideration has been given to the question of housing or building a house for himself. It would be taxing his labour resources too much if he is expected to build a habitable house for himself. Results would be more satisfactory if he is provided with a house when he is settled on the land. The cost of a two-roomed semi-permanent building will be about Rs. 250, so that cost per acre on a 5-acre unit will be Rs. 50. From these figures we itemize the inclusive cost of developing an acre of land as follows :—

(Inclusive cost of developing an acre of land in the dry zone for paddy : items).

	Rs.	c.
Jungle clearing per acre	35	0
Stumping per acre	30	0
Ridging and canalizing as explained in the article per acre	65	0
Wooden structures per acre	20	0
	150	0
Housing	50	0
Per acre	200	0

This will form the working basis for developing an acre of land.

In the selection of colonists it is preferable to get married men between the ages of 30 and 40 years. A married colonist with a family is more stable than a bachelor who by nature has a tendency to wander about. Also the unit of land to be finally settled on the colonist should be sufficiently large to give him an income to maintain himself and family well above the border line of destitution. It should secure him a decent living and help him to become a respectable member of the community. According to the present day cost of commodities, it is estimated that such a standard for a family of four members could be purchased for Rs. 22·50 per mensem augmented by a certain amount of home produce.

In accordance with the programme of development drawn up for a colonist he will have no income whatsoever from his allotment during the first six months of occupation on the land. At the end of the first year he will have a chena crop of 2½ acres, a gingelly crop and 2½ acres of paddy crop. At the end of the first half of the second year he will harvest 2½ acres of *maha* paddy ; end of the second year 2½ acres of paddy ; end of the first half of the third year 5 acres of paddy and at the end of third year 2½ acres of paddy. Then if any subsidy is given by Government it must be distributed as follows :—

First six months a family of 3 or more should receive Rs. 22·50 per month. Income from allotment = nil.

Second six months his income from chena is Rs. 8 per mensem on the basis of Rs. 20 per acre. Government grant Rs. 15 per mensem.

First half of second year at 40 bushels to an acre in new clearings and at Re. 1 ·50 per bushel his income is Rs. 25 per mensem. No Government grant is necessary from the second year onwards.

Thereafter he should be able to secure an average income of Rs. 25 per mensem from his allotment of 5 acres.

On this basis total money payments to a colonist will be Rs. 135 + Rs. 90 = Rs. 225 during the first year. For this the colonist is expected to do the following works on his land :—

		Rs.	c.
1st year : asweddumize according to the method explained in this article $2\frac{1}{2}$ acres at Rs. 65	..	162	50
2nd year : asweddumize $2\frac{1}{2}$ acres at Rs. 65	..	162	50
3rd year : stump 5 acres at Rs. 30 ..	..	150	0
		475	0

The difference of Rs. 250 between the direct payments to him and the work put into the land—which must be of the specified standard—will cover the cost of jungle clearing—Rs. 175, and Rs. 75 to cover the cost of portable wooden structures if it is decided to supply them ready made to the colonist, or it may be credited to him as his contribution towards his dwelling. The actual Government grant to a colonist will be Rs. 175 in building a house for him.

TRIALS WITH SOYBEAN IN CEYLON

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MUCH has been written in recent years on the virtues of the soybean, and it is not the object of this article to add to the catalogue of the uses to which it may be put. An article contributed to the local press (11) gave selections from this catalogue, and it is our intention to publish details of the ways in which the soybean can be used, as a part of the departmental propaganda programme. It will suffice here to state that the seed contains the vitamins A, B and D that are present in milk, that the sprouted seedling also contains vitamin C, that the seed is rich in calcium, sodium, manganese and phosphorus, and that its reserve food is in the form of protein, of which it contains 40 per cent., and oil (17 per cent.) whereas other pulses have very little of these substances, and store most of their reserves as starch or sugar. It can therefore be used in place of meat and it is of particular value to sufferers from diabetes.

The object of this article is to describe those experiments that have been carried out in order to determine the conditions under which the soybean is best grown in Ceylon. The greater part of the voluminous literature deals with its cultivation in temperate and sub-tropical climates, and, while the technique there used is invaluable as a basis on which to work, it is inevitable that modifications should be necessary under tropical conditions. It has also been necessary to choose between the enormous number of varieties that have been used or evolved in every country in which the cultivation of soybean has become established. Our trials are still in progress, but we have collected sufficient information to be able to make general recommendations, and it is hoped to deal with matters of detail in a subsequent article.

We have tried thirty-two varieties, varying considerably in size and colour. The largest has an average weight of 30 grammes per 100 seeds (or say 1,500 seeds to the pound) and the smallest weigh only 5 grammes per 100 seeds (9,000 seeds per pound). The colours include yellow, green, brown and black, and the seeds vary in shape from flattened to almost spherical,

and in hardness, the small seeds being generally harder than the large ones. It has been found convenient to divide the varieties into two main classes according to seed size, because other characters appear to be correlated with it. Generally speaking, the large-seeded varieties mature in 3–3½ months, the vegetative growth is poor so that they must be planted close together, the yield is not good, but the seeds are comparatively soft and easily cooked ; whereas the smaller-seeded varieties require 4–5½ months to mature, they can be planted fairly widely and will give a good volume of green material and also a good crop of seed, but the seeds are hard. One or two varieties with very small seeds are climbers and have a very long vegetative period and are suitable only as green manure or fodder plants.

The first trials were made with samples of seed and were perforce carried out in very small plots, so that statistical comparison of results was not possible. The primary object of the trials was acclimatization and multiplication of seed, but opportunity was taken to make general observations on factors that were likely to be of importance, to serve as a guide for more precise trials to be carried out at a later date. For example, the effect of lime was observed by treating alternate rows of plants and measuring the effect of the treatment on their subsequent growth. The method of observation was first to measure the height of the plants and to calculate a mean for each row which would serve as an index of plant size. Then the lime was applied (at the rate of 1 ton per acre) and similar measurements were made subsequently at fortnightly intervals. These measurements were converted into percentages of the first record for each row, so that the relative rates of growth were being compared and not the actual heights of the plants. The results of the trial are found in Table I. where it is seen that, of seven varieties measured, five showed a greater rate of growth as a result of the application of lime. A sixth (Hahto) should really show the same result ; but at the beginning of the trial, one of the rows of this plot (subsequently to be limed) was badly damaged by hare, which bit off the tops of the seedlings, and this row never recovered from this check on the growth of the plants ; if its records be omitted, the rest of the plot shows an advantage in favour of the limed rows. The conditions of the experiment did not permit of comparisons being made of the yield of seed. The effect of the lime was visible, a few days after its application, by an appreciable darkening of the colour of the foliage of the treated plants. Experience is general that lime stimulates the growth of leguminous plants.

The effect of spacing was first investigated with one of the small-seeded varieties, Poona Yellow, in a randomized block experiment. Three spacings were used—2 feet by 3 inches,

2 feet by 6 inches, and 2 feet by 12 inches,—and there were twelve replications of each set of treatments. The trial area was limed at the rate of one ton per acre, 2½ weeks before sowing ; a plot contained 3 rows each 3 feet long, and there were no gaps between plots. A month after sowing, the whole area was treated with nitrate of soda at the rate of one cwt. per acre. At harvest, a length of 2 feet was harvested from the middle row of each plot. The results are shown in Table II.; differences are significant, and the trial shows that the narrowest spacing (2 feet × 3 inches) is better than either of the others. The yield per plant is greatest at the widest spacing, but the increase is not sufficient to compensate for the smaller number of plants, and the conclusion is formed that planting in drills is to be preferred to " square " planting.

It will be noted that no mention has yet been made of inoculation of seed prior to sowing ; in neither the trials carried out nor the multiplication areas planted was the seed inoculated, and yet a yield equivalent to half a ton of seed per acre had been obtained with one small-seeded variety. The pathological division of the Agricultural Department has published two articles in this journal (12, 13) which suggested that plant growth was improved as a result of inoculation of seed prior to sowing, and that the green matter of these plants may contain a greater percentage of nitrogen, but it was not able to demonstrate that seed inoculation produced any increase in yield.

The question is of considerable importance to Ceylon, apart altogether from its scientific interest. The cultivator who grows soybean as part of a permanent rotation has no cause for worry, because he has only to sow inoculated seed once and his land will become inoculated with the necessary bacteria by the decay of nodules, thus rendering further inoculation of seed unnecessary. The chena cultivator is in a very different position ; he will grow soybeans on one area one year and on a different area the following year, and it becomes very important to him to know whether or not inoculation is necessary ; should it be so, he must either renew his seed for sowing each year or he must carry soil from one chena to the next ; failure to do one of these things would mean the failure of his crop, and of the soybean as a potential chena crop.

The trials next to be described were meant to provide more evidence on points already investigated, such as spacing and liming, and also to decide whether or not seed inoculation was necessary, or whether possibly the benefit conferred on the plant by the extra nitrogen manufactured by the bacteria could be conferred as easily by the addition of some form of combined nitrogen to the soil. There is a considerable literature on the subject of root nodules and the bacteria which produce

them, and the general opinion is that nitrifying bacteria and added nitrogen (particularly in the form of nitrates) are antagonistic in their action, because the addition of nitrate nitrogen to the soil results in a decrease of the number, size and efficiency of nodules on the roots of leguminous plants. Points of detail vary; Orcutt and Wilson (2) state that the addition of nitrate in quantities of 200 lb. per acre has a depressing effect on nodule formation, whereas quantities of 50–100 lb. per acre are associated with increased nodulation. Umbreit and Fred (5) on the other hand, state that even the latter quantities tend to prevent the formation of nodules but they suggest that the plant derives more benefit either from the nitrogen fixed by the nodules or from that added as nitrate, according to the conditions under which it is growing. Where the carbohydrate-nitrogen ratio in the plant is balanced, as it is under normal conditions, better results are obtained by inoculation; but where abnormal conditions such as drought or shortness of the growing season upset the carbohydrate-nitrogen balance, then it is preferable to add combined nitrogen to the soil.

The results of the interactions of nitrogen compounds and nodule-forming bacteria affect us only in their effect on agricultural practice in Ceylon, and since there appear to be conditions where inoculation of seed is not necessary, we are trying to determine whether those conditions exist in Ceylon, and if so, where.

Two trials of similar design were laid down at Jaffna and Anuradhapura in the *maha* 1938–39 season. They were of a somewhat complicated (factorial) design which allows the comparison of a large number of effects without excessive replication of treatments, by using combinations of treatments arranged according to a definite system. For example, the trials to be described each had only 32 plots, yet they compared the effects of five different treatments and also of any interactions between any numbers of treatments. The effects that were to be compared are tabulated below :—

	Jaffna	Anuradhapura
1. Variety :	Chame *vs.* Yellow I	Poona Yellow *vs.* Small seeded
2. Spacing :	1′ × 1′ *vs.* 1′ × 6″	2′ × 6″ *vs.* 2′ × 3″.

3. Inoculation : Seeds inoculated prior to sowing *vs.* not inoculated.
4. Manuring : Plots treated with nitrate of soda at the rate of 1 cwt. per acre *vs.* not treated.
5. Liming : Plots treated with lime at the rate of 1 ton per acre *vs.* not treated.

The varieties used in the Jaffna trial belong to the large-seeded class and were, therefore, planted more closely than the small-seeded ones grown at Anuradhapura. The trial at Jaffna was irrigated; that at Anuradhapura was not. The nitrate of soda was added in two doses; half, two weeks after sowing,

and the remainder two weeks later. The lime was added in one dose, two weeks before sowing. Two seeds were planted per hole. Each trial was of the 2^5 factorial design described by Yates (10) and was made up of thirty-two plots, representing all possible combinations between the five pairs of factors. The plots were randomized in four blocks, and certain high order interactions were confounded with block differences. The arrangement of the trials and the results are shown in Tables III, IV and V. At Anuradhapura the differences between the treatments did not reach the level required by the statistician and we are unable to say with confidence that the differences are not due to chance. At Jaffna the required level of significance was reached, and seven factors produced differences sufficiently large to be relied on. These differences are indicated by asterisks in Table IV and must be examined in greater detail (see also Table VI.).

1. *Spacing.*—The narrower spacing (1′ × 6″) gave a marked increase in yield over the wider spacing (1′ × 1′). The magnitude of this difference cannot be accepted without confirmation because there were sufficient gaps in the rows to cast some doubt on the actual spacing in the plots; but because the percentage of survivors in the two treatments differed by only 0·05 per cent. (being 77·56 per cent. at the wider spacing and 77·61 per cent. at the narrower) and because, in spite of gaps, the narrower spacing still gave the bigger yield, it is accepted that the narrower spacing is definitely to be preferred.

2. *Inoculation.*—The advantage of inoculation is very clearly indicated in this experiment; the result is of interest for two reasons—first, because it is the only trial in Ceylon in which a significant increase in yield has been obtained as a result of the inoculation of seed, and second, because it disagrees with the suggestion made by Park and Fernando (13) that the early-maturing varieties do not respond to inoculation; nevertheless, the size of the difference obtained in this trial entitles it to some consideration.

3. *Manuring.*—The effect of manuring is markedly less than that of seed inoculation, but it is still significant. It is possible that the magnitude of the effect could be altered by varying the amount of manure applied.

4. *Interaction between variety and spacing.*—An analysis of this effect (Table VI) indicates that the performance of the variety Yellow I was better than that of Chame at the narrower spacing, but that there was no difference between them at the wider one. If the narrow spacing is to be preferred then Yellow I is the better variety to use.

5. *Interaction between spacing and inoculation (Table VI.)*—The effect of inoculation is more marked at the narrower spacing.

6. *Interaction between variety and manuring.*—The variety Yellow I has responded to manuring hardly at all, but there has been a marked response from Chame.

7. *Interaction between inoculation and manuring.*—The effect of the addition of nitrate of soda is noticeable only in the absence of inoculation; the effect of inoculation is significant whether or not the plots are manured, but it is more marked in those plots that have not been manured. It is concluded that the effects of manuring with nitrate and of inoculation of seed are antagonistic, but that the effect of inoculation is the stronger, at least with the particular dose of nitrate applied in this experiment; where inoculation is not feasible, however, nitrate of soda may be added with good effect.

The general recommendations to be drawn from this trial are that the variety Yellow I may be recommended to be inoculated prior to sowing, and should be spaced not wider than $1' \times 6''$.

The absence of any definite effect of lime may perhaps be due to the fact that the soils of the Jaffna peninsula are, in general, calcareous and that the addition of one ton of lime per acre made no appreciable difference to the available lime content.

More trials of the kind described in the preceding paragraphs are being carried out, which it is hoped will confirm the general conclusions already formed and will also give more information on points of detail.

It has already been stated that nodule development and its reaction to treatment of different kinds, are of interest to us only in so far as they may affect agricultural practice. At the same time, we have examined samples of plants growing under the conditions of the Jaffna and Anuradhapura trials in order to observe any correlation between nodule development and yield of seed.

It is known that the nodule-forming bacteria can be divided into strains any one of which will produce effective nodulation on a limited number of host plants. Thus one strain is effective only on peas, vetches and lentils; another on *Vigna*, *Arachis*, *Lespedeza* and *Phaseolus*; while the soybean strain is said not to affect any other plant. Ruf and Sarles (9) examined soybean plants that had been inoculated with effective and ineffective strains of bacteria, and found that an effective strain produced fewer but larger nodules concentrated round the base of the tap root, whereas an ineffective strain produced more and smaller nodules scattered over the entire root system. In our experiments we used only one strain of bacterium, which had previously been determined to be effective, but we also used other treatments which we considered might be equivalent to inoculation

with an ineffective strain ; we therefore adopted Ruf and Sarles' criterion of effectiveness and classified accordingly the plants growing under our different treatments. Plate I. shows the scheme of classification devised by Ruf and Sarles ; according to them, an effective strain of bacterium (*i.e.* good inoculation) would produce few large nodules, situated mostly in area A1, with a few in B1 and A2. Our classification was perhaps more strict, because we were comparing treatments that might be expected to produce greater differences than those of Ruf and Sarles' experiments. We examined 20 plants of each treatment, counting and weighing the nodules, and classifying their distribution on the plant. The results appear in Table VII, and, since only main effects are required, have been averaged in the lower half of the table ; the averages are not only more easily interpreted, but are also of greater accuracy, because they are means of eighty readings.

The results show a general agreement with those of other workers. The inoculated plants show a better distribution of nodules according to Ruf and Sarles' classification than do the uninoculated ones ; if we take the areas A1 + B1 + A2 as areas indicating efficient inoculation, we find that they represent 61·5 per cent. of the total in the inoculated series, but only 48 per cent. in the uninoculated series. The nodules are fewer in the inoculated series (agrees with Ruf and Sarles) but they are not larger. The effect of manuring agrees with the finding that the addition of combined nitrogen depresses nodulation. The unmanured series have the better nodule distribution (A1 + B1 + A2 = 60 per cent. for unmanured treatments and 49·5 per cent. for manured treatments), and they have fewer and bigger nodules. The effect on nodulation of the addition of lime is much less marked. There is no difference between distribution (A1 + B1 + A2 is 54·25 per cent. for the limed series and 55·25 per cent. for the unlimed series) and only a small difference in weight and number of nodules, but both differences are in favour of liming.

SUMMARY.

The results of preliminary investigations into the technique of soybean cultivation in Ceylon suggest—

(1) that the beans should be drilled at distances which will vary with the size of seed sown.

(2) that inoculation of seed prior to sowing is beneficial but not essential.

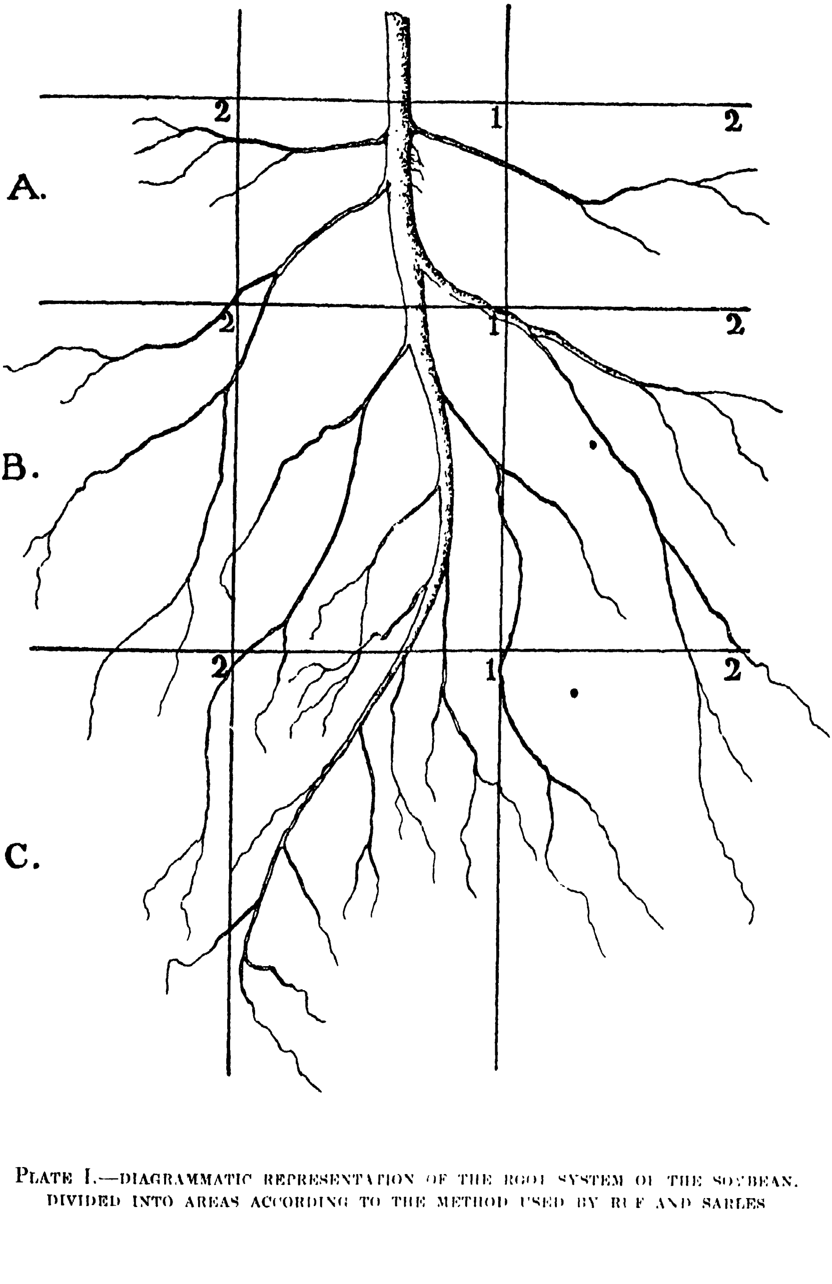

PLATE I.—DIAGRAMMATIC REPRESENTATION OF THE ROOT SYSTEM OF THE SOYBEAN, DIVIDED INTO AREAS ACCORDING TO THE METHOD USED BY RUF AND SARLES

(3) that where inoculation is impracticable, a smaller increase in yield may be obtained by manuring with nitrate of soda.

(4) that lime is beneficial.

I have pleasure in recording my indebtedness to Mr. W. N. Fernando of this division for general supervision of these trials, and to the Agricultural Officer, Northern, and his Farm Managers at Anuradhapura (Mr. E. S. Jayasundera) and Jaffna (Mr. K. Balasingham) for their co-operation in the trials at those stations.

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TABLE I.

Effect of lime on development of soybean plants

Short-aged varieties.

	Easycook.			Rokusan.			Chame.			Hahto.		
	1	2	3	1	2	3	1	2	3	1	2	3
Average of limed rows	6·39	9·93	11·12	13·15	20·61	21·95	13·52	26·00	27·75	12·82	17·08	18·42
	100	**155**	**174**	**100**	**157**	**167**	**100**	**192**	**205**	**100**	**133**	**144**
Average of whole plot	6·64	9·87	11·06	13·33	20·05	21·48	13·91	25·80	27·57	13·37	18·18	19·62
	100	**149**	**167**	**100**	**150**	**161**	**100**	**185**	**198**	**100**	**136**	**147**
Average of unlimed rows	7·00	9·80	10·98	13·50	19·57	21·07	14·47	25·46	27·27	14·12	19·68	21·25
	100	**140**	**157**	**100**	**145**	**156**	**100**	**176**	**188**	**100**	**139**	**150**

Long-aged varieties.

	Brown.					Yellow.					Black.				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Average of limed rows	12·86	33·86	77·89	86·07	93·21	8·41	15·64	24·15	33·53	37·07	9·54	26·59	46·04	63·50	69·00
	100	**263**	**606**	**669**	**725**	**100**	**186**	**287**	**399**	**441**	**100**	**279**	**483**	**666**	**723**
Average of whole plot	12·81	31·86	71·97	81·95	88·19	8·37	15·24	23·17	32·93	37·41	9·61	26·62	43·82	60·26	66·65
	100	**249**	**562**	**640**	**688**	**100**	**182**	**276**	**393**	**447**	**100**	**277**	**456**	**627**	**693**
Average of unlimed rows	12·62	27·86	61·00	73·71	76·71	8·29	14·43	21·19	31·57	38·14	9·75	26·71	39·94	54·19	62·25
	100	**221**	**483**	**584**	**608**	**100**	**174**	**256**	**381**	**460**	**100**	**274**	**410**	**556**	**638**

The figures in ordinary type represent the average height of the plants in these rows, in centimeters. Each figure in heavy type represents the height recorded in the line above, expressed as a percentage of the height in the first column of each table, and thus expresses the average rate of growth. The first measurement (column 1 in each case) was made before the lime was applied; the other measurements were made at regular intervals after the application of lime.

TABLE II.

Spacing trial with soybeans—Yields of seed. Season *yala* 1939

Yield in ounces.

Spacing.	Replications. 1	2	3	4	5	6	7	8	9	10	11	12	Total.
$2' \times 3''$	1·25	2·00	1·50	3·75	2·25	2·25	2.50	3·00	3·00	5·00	2·25	1·50	30·25
$2' \times 6''$	1·00	1·00	1·00	3·00	2·75	1·75	2.75	2·00	1·75	1·00	2·00	1·00	21·00
$2' \times 12''$	1·25	1·25	1·00	3·00	3·00	1·50	0.75	1·25	1·25	1·50	0·50	1·25	17·50

The odds are 100 to 1 that the differences are significant, and that the $2' \times 3''$ spacing has given a significantly bigger yield than that at $2' \times 12''$. The odds are 20 to 1 that the yield at $2' \times 3''$ is significantly better than that at $2' \times 6''$. The difference between the yields at $2' \times 6''$ and $2' \times 12''$ is not significant.

TABLE III.

Design of trials at Anuradhapura and Jaffna and yield of each plot in lb.

Anuradhapura.									Jaffna.							
ay-im 4·34	bylim 4·61	bxli- 5·58	bx- -m 4·42	ayl- - 4·27	ax-i- 5·03	by- - - 6·20	axl-m 5·16	Block I. ..	ayli- 2·37	bxl- - 1·12	axl.m 1·87	by- i- 3·06	ax- - - 0·62	byl-m 2·06	bx-im 1·87	ay- -m 1·81
axl- - 4·03	bx - - - 4·70	ax-im 4·09	bxlim 3·64	ay-i- , 3·86	ayl-m 5·00	by - -m 3·98	byli- 4·25	Block II. .	by-im 2·87	aylim 2·81	bx-i- 2·06	bxl-m 1·37	ax- -m 1·75	axli- 1·69	byl - - 1·62	ay--- 1·31
ayli- 3·69	bxl- - 4·73	ay- -m 4·70	by- i- 5·27	byl-m 5·20	axlim 4·77	ax- - - 5·19	bx-im 5·87	Block III.	by- -m 1·94	ay-i- 2·31	ayl-m 1·69	byli- 3·00	bx- - - 0·56	ax-im 2·00	bxlim 0·87	axl- - 0·75
axli- 5·87	bx-i- 6·03	ax--m 5·02	byl- - 4·27	by-im 5·31	bxl-m 5·31	aylim 4·03	ay - - - 3·05	Block IV. ..	bxli- 1·62	ax-i- 1·75	by - - - 1 87	bylim 3·25	ay-im 2·94	bx - -m 1·75	axl-m 1·25	ayl - - 10·6

a : small seeded , b : Poona Yellow
x : $2' \times 3''$; y : $2' \times 6''$; l : limed
i : inoculated ; m : manured.
Size of plot $20' \times 16'$, or 10 rows per plot ; harvested area $16' \times 15'$ or 8 rows per plot.
The mean yield is at the rate of 860 lb. per acre.

a : Chame ; b : Yellow I
x : $1' \times 1'$; y : $1' \times 6''$; l : limed
i : inoculated ; m : manured.
Size of plot $24' \times 7'$, or 7 rows per plot ; harvested area $22' \times 5$, or 5 rows per plot.
The mean yield is at the rate of 728 lb. per acre.

TABLE IV.

Effects of main treatments and first-order interactions in lb. of seed

	Difference in yield. Anuradhapura.	Jaffna.
Yellow I—Chame	..	2·91
Poona Yellow—Small seeded	7·27	..
Narrow spacing—wide spacing	7·41	13·07 ** (= 323 lb./ac.)
No liming—liming	2·65	2·07
Inoculation—no inoculation	1·01	13·81 ** (= 342 lb./ac.)
Manuring—no manuring	—0·57	5·33 ** (= 132 lb./ac.)
Interaction between—		
variety and spacing	+5·03	+3·83*
variety and liming	—5·73	—0·07
spacing and liming	—0·13	+1·57
variety and inoculation	+2·49	—1·19
spacing and inoculation	—3·63	+4·69**
liming and inoculation	—4·07	—0·69
variety and manuring	—4·81	—3·19*
spacing and manuring	+5·19	+0·21
liming and manuring	+2·63	—1·45
inoculation and manuring	—5·27	—4·09*
Level of significance 1 per cent.	10·94	4·30
5 per cent.	7·85	3·09

None of the differences in the Anuradhapura trial reached the necessary level of significance, and therefore they cannot be relied on. In the Jaffna trial seven differences are greater than the significant level. The odds are 100 to 1 that those differences marked with two stars are real ones, and 20 to 1 on those marked with a single star.

TABLE V.

Analysis of variance of soybean trials

	Jaffna. DF.	Jaffna. Sum of Squares.	Jaffna. Mean Square.	Anuradhapura. DF	Anuradhapura. Sum of Squares.	Anuradhapura. Mean Square.
Blocks	3	0·4668	0·1556	3	3·1416	1·0472
Main effects and first order interactions	15	14·7744	0·9849	15	9·2182	0·6145
Remainder	13	0·8291	0·0628	13	5·3619	0·4125
Total	31	16·0703		31	17·7217	

TABLE VI.

Effect of interaction between factors

Yields are in lb.

Variety and spacing.—

	1′ × 6″	1′ × 1′	
Yellow I.	19·67	11·22	30·89
Chame	16·30	11·68	27·98
	35·97	22·90	58·87

Spacing and inoculation.—

	Inoculated.	Not inoculated.	
1′ × 6″	22·61	13·36	35·97
1′ × 1′	13·73	9·17	22·90
	36·34	22·53	58·87

Variety and manuring.—

	Manured.	Not manured.	
Yellow I.	15·98	14·91	30·89
Chame	16·12	11·86	27·98
	32·10	26·77	58·87

Inoculation and manuring.—

	Manured.	Not manured.	
Inoculated	18·48	17·86	36·34
Not inoculated	13·62	8·91	22·53
	32·10	26·77	58·87

TABLE VII.

Effect of treatment on nodule development and distribution

Treatment.	Percentage Distribution of nodules. A1	B 1	C 1	A 2	B 2	C 2	Mean Number of nodules per plant.	Mean weight of nodules per plant in gm.	Mean weight per nodule in gm.
No treatment	28	13	1	17	23	18	27·0	0·092	0·0034
Inoculated	42	12	—	18	17	11	43·2	0·075	0·0017
Manured	21	9	1	9	36	24	45·1	0·120	0·0026
Limed	23	14	3	14	27	19	26·7	0·141	0·0053
Inoculated and manured	25	9	2	18	28	18	36·6	0·064	0·0017
Inoculated and limed	30	16	3	13	23	15	30·6	0·115	0·0032
Manured and limed	22	12	1	10	31	24	60·1	0·112	0·0019
Inoculated, manured and limed	39	12	1	12	22	14	18·6	0·034	0·0018
Averages :—									
Inoculated	34	12·25	1·5	15·25	22·5	14·5	32·25	0·072	0·0021
Not inoculated	23·5	12	1·5	12·5	29·25	21·25	39·725	0·116	0·0033
Manured	26·75	10·5	1·25	12·25	29·25	20	40·1	0·082	0·0020
Not manured	30·75	13·75	1·75	15·5	22·5	15·75	31·875	0·106	0·0034
Limed	28·5	13·5	2·0	12·25	25·75	18	34·0	0·100	0·0030
Not limed	29	10·75	1·0	15·5	26	17·75	37·975	0·088	0·0023

NOTES ON ORCHIDS CULTIVATED IN CEYLON RENANTHERA LOWII

E. PERERA,
CURATOR, HENARATGODA BOTANIC GARDENS

RENANTHERA LOWII, the *Vanda Lowii* of many gardens, is placed in the genus *Arachnanthe* by Bentham. This most remarkable and rare Orchid grows on high trees in the humid forests of Borneo. It is distinct in growth from any other species, and is readily known by its climbing stem an inch in thickness, which emits stout fleshy roots from the lower part, by its numerous obliquely obtuse, strap-shaped, leathery, dark-green leaves 2 to 3 feet long, and by its remarkably long, drooping, slightly-hairy flower spikes, which attain from 6 to 12 feet in length and bear from forty to fifty flowers on each.

The most remarkable feature of the plant is the production of dimorphous flowers, that is, of two dissimilar forms of flower on the same spike. The two blossoms at the base of the spike, which are separated widely from the rest, are of a tawny-yellow, spotted with crimson, and have the sepals and petals lanceolate, recurved and bluntish. The rest of the numerous flowers, which are 3 inches across, have lanceolate, acute recurved, wavy sepals and petals of a greenish-yellow, marked throughout by large irregular blotches, mostly transverse, of a rich dark-brown. The flowers remain fresh for several weeks.

Culture.—These plants are of easy culture and if properly attended to seldom fail to do well. Their natural home is upon the branches of forest trees. They can be successfully grown upon blocks of wood or in shallow baskets. They are found to do well in fairly large pots or tubs. These should be three-fourths filled with clean potsherds and charcoal, and the remainder with clean fresh sphagnum.

During the growing season, abundance of moisture, both at the root and in the atmosphere, is indispensable. When at rest the plants require much less water, but it is important that they should not be allowed to get dry at any time.

They thrive best under semi-shade conditions and should not be allowed to come under the direct rays of the sun.

These plants should be kept free from insects, especially from the different kinds of scale insects. There is a small kind in particular which is apt to infest them, and which, if allowed to increase, will speedily make the plants look yellow and unhealthy. It may be controlled by washing with warm water and soft soap, applied with a sponge, and left on the leaves for some time, when all remains of the soap should be removed with clean water.

RENANTHERA LOWII.

PADDY CULTIVATION

WE published in the last number of *The Tropical Agriculturist* the Cultivation Sheets in respect of an area cultivated in paddy at the Experiment Station, Anuradhapura. In this number we publish similar information in respect of the Paddy Seed Station, Paranthan, for the *sirupokam* season of 1938 and the *kalapokam* season of 1938–39.

It should be noted that out of the 49¼ acres cultivated for *kalapokam* 1938–39, 20¼ acres had been cultivated for *sirupokam* 1938.

Division : Northern.

Name of Station : Paddy Seed Station, Paranthan.

Acreage under Paddy : 46½ acres.

Season : Sirupokam 1938.

Variety of Paddy : Pachchai Perumal (2462/11).

I.—LABOUR.—

Operation	Men at 75 cts.	Boys at 30 cts.	Total. Rs. c.	Cost per Acre. Rs. c.
1. Nurseries for transplanting	—	—	—	—
2. Ploughing and mudding	177	—	132 75	2 85½
3. Work on bunds and channels	167	—	125 25	2 69
4. Mammotying of unploughable areas	—	—	—	—
5. Harrowing	87	—	65 25	1 40
6. Levelling	176	—	132 0	2 84
7. Applying manures	80½	—	60 37	1 30
8. Cutting, transporting and applying green manures	—	—	—	—
9. Sowing	30	—	22 50	0 48
10. Weeding, thinning out and filling vacancies	61	—	45 75	0 98½
11. Irrigating and watching	205	—	153 75	3 31
12. Scaring birds and monkeys	—	47½	14 25	0 31
13. Harvesting 14. Transporting and stacking	On contract at Rs. 5·45 per acre		253 42	5 45
15. Threshing and winnowing	239½	—	179 62	3 86
16. Drying, measuring and transporting to store	53	—	39 75	0 85½

Operation	Men at 75 cts.	Boys at 30 cts.	Total. Rs. c.	Cost per Acre. Rs. c.
17. Pest and disease work ..	107½ ..	—	.. 80 62 ..	1 73
18. Contribution to Communal works ..	— ..	—	.. — ..	—
19. Fencing including repairs	23½ ..	—	.. 17 62 ..	0 38

II.—SEED 93 bushels at Re. 1·50 per bushel .. 139 50 .. 3 0

III.—MANURES.—

Artificial manure : 43½ cwt. of Nicifos 17/41 at Rs. 10·80 per cwt. .. .. .. 469 80 .. 10 10½

IV.—DEPRECIATION ON IMPLEMENTS—vide Statement A .. .. .. 92 5 .. 1 98

V.—COST OF ANIMAL LABOUR—vide Statement B .. 234 5 .. 5 3½

VI.—OVERHEAD CHARGES.—

Salary of Foreman for 3 months at Rs. 840 per annum and 2 months at Rs. 600 per annum .. 310 0 .. 6 67

VII.—MISCELLANEOUS.—

Cost of string 30 lb. coir rope and 28 lb. coir string	..	3 67 ..	0 8
Cost of kerosene, 13 bottles ..	..	2 8 ..	0 4½
All other unspecified items ..	..	1 0 ..	0 2
TOTAL COST OF PRODUCTION		2,575 5	55 38

Total yield : 1,642 bushels 16 measures.
Yield per acre : 35 bushesls 10½ measures.
Cost of cultivation per acre : Rs. 55·38.
Cost of production of 1 bushel of paddy : Re. 1·57.

Straw.

Yield of straw : 44,309 lb. or 395½ cwt.
Value of straw : Rs. 401·42.
Value realized by sale of straw : Rs. 346·24.
Value of straw used at the station : Rs. 55·18.

Remarks.

The yields this season have been the highest ever recorded on this station both for a *sirupokam* or a *kalapokam* crop, although the undernoted two factors were adverse towards a still better yield.

(1) Severe set back caused by the damage at the early stages of the crop by the paddy swarming caterpillar.
(2) Heavy infestation of land with *Kora* weed. Efforts are being taken to eradicate this weed by (*a*) hand weeding, (*b*) repeatedly ploughing the weed and killing it by exposure.

Yield figures of sirupokam, 1937.—46 acres yielded 1,564 bushels 16 measures *i.e.*, yield of 34 bushels ⅓ measure per acre.

STATEMENT A.

Depreciation on Implements

Implements.	A No. in use.	B Cost Price each.	C Length of working life years.	D Total Depreciation. $\frac{A \times B}{C}$	E No. of working days per annum.	F No. of days worked for *sirupokum* 1938 paddy season	G Cost for season. $\frac{D \times F}{E}$	H Cost of replacement of parts and costs of repairs during season.	Nett Depreciation.
		Rs. c.		Rs. c.			Rs. c.	Rs. c.	Rs. c.
1. Ploughs—									
Type *a* Ceros ..	4	31 25	6	20 83½	127	57	9 35	20 0	29 35
b Victory ..	1	35 0	6	5 83½	127	57	2 62	5 0	7 62
2. Burmese harrows	8	2 50	2	10 0	102	45	4 41	0 75	5 16
3. Yokes —									
a ordinary ..	10	1 0	2	5 0	127	57	2 24	—	2 24
b improved ..	—	—	—	-	-	—	--	-	--
4. Levelling boards									
a large ..	2	5 0	2	5 0	63	30	2 38	0 75	3 13
b band ..	6	1 0	2	3 0	79	46	1 75	0 75	2 50
5. Mammoties ..	66	1 50	5	19 80	—	182½	9 90	0 75	10 65
6. Harvesting knives ..	11	1 0	5	2 20	—	—	—	—	--
7. Threshing mats .	1	25 0	4	6 25	94	36	2 39	0 75	3 14
8. Winnowing machine ..	1	20 0	5	4 0	--	—	-	---	—
9. Gunny bags ..	1,300	0 12	3	52 0	—	182½	26 0	1 50	27 50
10. Hurricane lamps	3	3 20	6	1 60	94	36	0 61	0 15	0 76
Total ..									92 5

STATEMENT B.

Cost of Animal Labour.

1.—Bulls

Description.	A No.	B Cost of each.	C Estimated length of life. Years.	D Depreciation per annum. $\frac{A \times B}{C}$	E Food cost per annum.	F Cost of cattle keepers per annum.	G Total cost per annum D+E+F.	H No. of working days per annum.	I No. of working days for *sirupokum*. 1938 season.	J Nett cost for season. $\frac{G \times I}{H}$
		Rs. c.		Rs. c.	Rs. c.	Rs. c.	Rs. c.			Rs. c.
(*a*) Kangayam older pair ..	2	75 0	4	37 50	348 72	—	417 47	365	51	58 33
(*b*) Ditto young pair ..	2	125 0	8	31 25						
(*c*)										
(*d*)										
Total ..										**58 33**

2 .—Buffaloes

STATEMENT B.—*contd.*

Cost of Animal Labour.

Description.	A No.	B Cost of each.	C Estimated length of life. Years.	D Depreciation per annum $\frac{A \times B}{C}$	E Food cost per annum.	F Cost of cattle keepers per annum.	G Total cost per annum D+E+F.	H No. of working days per annum.	I No. of working days for *sirupokam* 1938 season	J Nett cost for season. $\frac{G \times I}{H}$
		Rs. c.		Rs. c.	Rs. c.	Rs. c.	Rs. c.			Rs. c.
(1) 9 year old buffaloes	2	30 0	3	20 0						
(2) 8 ,,	2	25 0	4	12 50						
(3) 8 ,,	1	30 0	4	7 50						
(4) 8 ,,	1	40 0	4	10 0	Grazed					
(5) 7 ,,	1	30 0	5	6 0	by					
(6) 7 ,,	1	35 0	5	7 0	cattle					
(7) 5 ,,	6	30 0	7	25 71	keeper	270 0	416 0	232	98	175 72
(8) 5 ,,	1	45 0	7	6 43						
(9) 5 ,,	4	40 0	7	22 86						
(10) 4 ,,	2	40 0	8	10 0						
(11) 4 ,,	1	35 0	8	4 38						
(12) 4 ,,	2	30 0	8	7 50						
(13) 3 ,,	1	25 0	9	2 78						
(14) 3 ,,	1	30 0	9	3 34						
Total ..				146 0						175 72

Total cost of bulls and buffaloes for *sirupokam* 1938 season, Rs. 234·05.

Division : Northern.

Name of Station : Paddy Seed Station, Paranthan.

Acreage under Paddy : 49¼ acres.

Season : Kalapokam 1938–39.

Variety of Paddy : (Vellai Illankalayan 47¼ acres ; G 18 *Molagu Samba* 2 acres.

I.—LABOUR.—

Operation.	Men at 75 cts	Boys at 40 cts.	Total. Rs. c.	Cost per Acre. Rs. c.
1. Nurseries for transplanting	— ..	— ..	— ..	—
2. Ploughing and mudding .	218 ..	— ..	163 49..	3 32
3. Work on bunds and channels ..	338½..	— ..	253 73..	5 15
4. Mammotying of unploughable areas ..	— ..	— ..	— ..	—
5. Harrowing ..	68 ..	— ..	51 1..	1 4
6. Levelling ..	237½..	— ..	178 91..	3 63
7. Applying manures ..	130 ..	— ..	97 49..	1 98
8. Cutting, transporting and applying green manures	78 ..	— ..	58 52..	1 19
9. Sowing or transplanting ..	33½..	— ..	25 13..	0 51

Operation	Men at 75 cts.	Boys at 40 cts.	Total. Rs. c.	Cost per Acre. Rs. c.
10. Weeding, thinning out and filling vacancies ..	241 ..	— ..	180 12..	3 66
11. Irrigating and watching .	169½..	— ..	135 50..	2 75
12. Scaring birds and monkeys	— ..	11 ..	4 40..	0 9
13. Harvesting ..	217½..	— ..	161 0..	3 27
14. Transporting and stacking	159½..	— ..	118 10..	2 40
15. Threshing and winnowing	347½..	— ..	255 83..	5 19
16. Drying, measuring, and transporting to store ..	63½..	— ..	46 2..	0 93½
17. Pest and disease work ..	— ..	— ..	— ..	—
18. Contribution to Communal works ..	— ..	— ..	— ..	—
19. Fencing including repairs	30½..	— ..	22 86..	0 46½
II.—SEED 106¾ bushels at Re. 1·50 per bushel		— ..	160 13..	3 25

III.—MANURES.—

	Rs. c.		
Artificial manures : 32·75 cwt. of Nicifos at Rs. 10·69 per cwt.	350·10		
51·57 cwt. of steamed bone meal at Rs. 4·51 per cwt.	232·59		
		582 69..	11 83
Other manure : 370 lb. of Sunnhemp seed at 12 cts. ..		44 40..	0 90
IV.—DEPRECIATION ON IMPLEMENTS—vide Statement C		95 4..	1 93
V.—COST OF ANIMAL LABOUR—vide Statement D ..		357 67..	7 26
VI.—OVERHEAD CHARGES.—			
Salary of Foreman for 6 months at Rs. 600 per annum..		300 0..	6 9
VII.—MISCELLANEOUS.—			
Cost of 37 lb. coir string and 63 lb. coir rope ..		6 22..	0 13
Cost of kerosene 16 bottles		2 96..	0 6
All other unspecified items: 150 baskets at 20 cts. ..		3 0..	0 6
TOTAL COST OF PRODUCTION		3,304 22	67 9

Total yield : 2,251 bushels, 16 measures.
Yield per acre : 45 bushels, 22 9/10 measures.
Cost of cultivation per acre : Rs. 67·09.
Cost of production of 1 bushel of paddy : Re. 1·47.

Straw.

Yield of straw : 83,900 lb. or 749 cwt. 12 lb.
Value of straw : Rs. 749·11.
Value realized by sale of straw : Rs. 654·35..
Value of straw used at the station : Rs. 94·76.

Remarks.

General.—The yield this season is very encouraging—the average yield per acre being 45 bushels 22 measures over an area of 49¼ acres and the average cost of production per bushel of paddy working at Re. 1·47 as against 34⅓ bushels over an area of 61 acres with the average cost of production per bushel working at Re. 1·74 for the *kalapokam* 1937–38.

Taking the varied disadvantages that the land is subjected to, the yield is a record one for *kalapokam* crop. If the cost of cultivation is considered high it is entirely due to the undeveloped condition of some of the areas and the treacherous growth of weeds like *Kora* and *Kudamatte* which abound in these fields. The eradication of these noxious weeds is in hand. In carrying out this season's cultivation the officer in charge carried out various trials which he thought would tend towards increased yields. The results of the trials were very encouraging.

From his studies it has been clearly observed that these soils require organic material, and above all a paddy crop requires the tender care and attention of its grower from sowing to harvest. The trials carried out are detailed below.

Weather conditions.—Except for the early showers of rain that fell at the beginning of the north-east monsoon, this season has been a dry period compared with the previous *kalapokam*. But this was no great disadvantage as the weather experienced between January 8th–24th, 1939, within which period there was rain almost every day spoiling fertilization of the crop to a great extent. It was during this period that nearly 27 acres of the crop were in flower. Had it not been for these unseasonal rains still greater yields may have been expected.

Results under Different Treatments.

Area in acres	Variety.	Treatment given for *kalapokam*.	Total yield Bush.	Total yield Meas.	Yield per Acre. Bush.	Yield per Acre. Meas.
7¼	*Vellai Illankalayan*	Manured with Sunnhemp material grown for seed and 1½ cwt. steamed bone meal and ¾ cwt. Nicifos	324	16	44	24
8½	Do.	Manured with Nicifos at 1 cwt per acre	404	16	47	18¾
10½	Do.	Manured with Nicifos at 1½ cwt. per acre	411	16	39	6
½	do.	Manured with Kavilai grown *in situ* and 1½ cwt. Nicifos	22	0	44	0
2	G 18 *Molagu Samba*	Manured with Sunnhemp material grown for seed and 1½ cwt. steamed bone meal and ¾ cwt. Nicifos per acre	97	0	48	16
1	*Vellai Illankalayan*	Ploughed in unflowered B 11 paddy and 1½ cwt. steamed bone meal	54	16	54	16
2	Do.	Cattle penned and 15 cart-loads of Kavilai cuttings from fruit area and 1½ cwt. steamed bone meal	101	0	50	16
7¼	Do.	Cattle penned and 16 cart-loads of compost and 1½ cwt. steamed bone meal per acre	286	0	39	14
1	Do.	Manured with 16 cart-loads of Dhall cuttings from fruit area and 2 cwt. steamed bone meal per acre	37	0	37	0
9¼	Do.	Sunnhemp grown and ploughed in and 2 cwt. of steamed bone meal per acre	473	16	51	6

STATEMENT C.

Depreciation on Implements.

Implements.	A No. in use.	B Cost Price each.	C Length of working life. years.	D Total Depreciation. $\frac{A \times B}{C}$	E No. of working days per annum.	F No. of days worked for *kalapokam* 1938–39 paddy season.	G Cost of *kalapokam* 1938–39 season. $\frac{D \times F}{E}$	H Cost of replacement of parts and costs of repairs during season.	Nett depreciation.
		Rs. c.		Rs. c.			Rs. c.	Rs. c.	Rs. c.
1. Ploughs—									
Type—Ceres ..	6	31 25	6	31 25	122	65	16 65	22 0	38 65
2. Byrmese harrows	8	2 50	2	10 0	82	37	4 51	0 75	5 26
3. Yokes—	10	1 0	2	5 0	122	65	2 66	—	2 66
4. Levelling boards—									
a large ..	2	5 0	2	5 0	62	32	2 58	0 75	3 33
b band ..	6	1 0	2	3 0	100	54	1 62	0 75	2 37
5. Mammoties ..	36	1 50	5	10 80	-	182½	5 40	0 75	6 15
6. Harvesting knives ..	11	1 0	5	2 20	-	182½	1 10	0 55	1 65
7. Threshing mats .	3	20 0	5	12 0	73	37	6 8	0 75	6 83
8. Winnowing machine ..	1	20 0	5	4 0	—	—	—	—	—
9. Gunny bags ..	1,300	0 12	3	52 0	-	182½	26 0	1 50	27 50
10. Hurricane lamps	2	3 20	6	1 7	73	37	0 54	0 10	0 64
Total ..									95 4

STATEMENT D.

Cost of Animal Labour.

1.—Bulls

Description	A No.	B Cost of each.	C Estimated length of life years.	D Depreciation per annum. $\frac{A \times B}{C}$	E Food cost per annum.	F Cost of cattle keepers per annum.	G Total cost per annum D+E+F.	H No. of working days per annum.	I No. of working days for *kalapokam* 1938–39 season.	J Net cost for *kalapokam* 1938–39 season. $\frac{G \times I}{H}$
		Rs. c.		Rs. c.	Rs. c.	Rs. c.	Rs. c.			Rs. c.
(*a*) Kangayam	2	125 0	8	31 25	382 50	270 0	776 87	365	65	138 35
(*b*) Nellore ..	2	182 50	8	45 62						
(*c*) Nellore ..	2	190 0	8	47 50						
Total ..	6			124 37	382 50	270 0	776 87			138 35

STATEMENT D.—*contd.*

Cost of Animal Labour.

2.—Buffaloes

Description.	A No.	B Cost of each.	C Estimated length of life years.	D Depreciation per annum. $\frac{A \times B}{C}$	E Food cost per annum.	F Cost of cattle keepers per annum.	G Total cost per annum D+E+F.	H No. of working days per annum.	I No. of working days for *kalapokam* 1938–39 season.	J Nett cost for *kalapokam* 1938–39 season. $\frac{G \times I}{H}$
		Rs c.		Rs. c.	Rs. c.	Rs. c.	Rs. c.			Rs. c.
(*a*) 9 year old buffaloes in 1937 ..	2	30 0	3	20 0						
(*b*) 8 ,,	1	25 0	4	6 25	grazed					
(*c*) 8 ,,	2	30 0	4	15 0	by					
(*d*) 8 ,,	1	40 0	4	10 0	cattle					
(*e*) 7 ,,	1	30 0	5	6 0	keeper	270 0	412 96	209	111	219 32
(*f*) 7 ,,	1	35 0	5	7 0						
(*g*) 5 ,,	5	30 0	7	21 43						
(*h*) 5 ,,	4	40 0	7	22 86						
(*i*) 5 ,,	1	45 0	7	6 43						
(*j*) 4 ,,	2	30 0	8	7 50						
(*k*) 4 ,,	1	35 0	8	4 38						
(*l*) 4 ,,	2	40 0	8	10 0						
(*m*) 3 ,,	1	25 0	9	2 78						
(*n*) 3 ,,	1	30 0	9	3 33						
Total ..	25			142 96		270 0	412 96	209	111	219 32

Total cost of bulls and buffaloes for *kalapokam* 1938–39 season Rs. 357·67.

SEASONAL PLANTING NOTES

CALENDAR OF WORK FOR OCTOBER AND NOVEMBER

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THE month of October brings us to the north-east rainy period which extends over the whole Island. During this period planting and transplanting of all varieties of material can be undertaken from the small seedling to quite fair-sized shrubs.

It is not always the actual amount of rain we get that matters so much for the transplanting as the fact that atmospheric conditions change from the pre-monsoon periods. The temperature drops considerably and conditions become moist and saturated so that the plants are liable to get a quick recovery from the jolt in shifting from pots or beds to a permanent position.

In the drier parts of the Island the October conditions begin the chief and often the only season for cultivation, and most vegetables can be given a start at this period. Tobacco seed should be sown for later planting, and cotton sowings are now done. Flower garden subjects should now be put in and hedges renewed where either seed or cuttings are necessitated for the purpose. Cannas planted now should flower at the end of November and remain so till the end of the north-east, *i.e.*, April-May next. Fruit trees too, whether imported, bought locally or raised on the spot, should go in this month to reap the full benefit of the subsequent rainy months of November and December. Too much importance cannot be given to this point, whether in wet or dry zone, as so often this planting or transplanting is delayed, often till the end of December, with the result that the newly planted subject gets insufficient time to establish itself and get its roots moving in the soil before unfavourable conditions assert themselves once again. Always be prompt in utilizing favourable weather where planting or transplanting is concerned.

Up-country, the same principle applies, but with slight modifications as the larger percentage of plantings here comprise seedlings of annuals which have been sown in beds or boxes

in September and later pricked out in beds to harden off. Those tender and of a succulent nature in the seedling should be given some overhead protection after planting to ward off any ill-effect of heavy downpours of rain, and the same applies to vegetables of a succulent nature such as lettuce and Cruciferae vegetables which will further need protection against cut-worm attacks also. Mildew or damping off is a frequent cause of loss in young seedlings of flowers and vegetables and a precautionary dusting every 3 or 4 days with flowers of sulphur saves many young seedlings. For pot work, geraniums, pelargoniums, gloxinia, and cinerarias make a good show and these should now be potted and grown on, increasing the size of the pot at each time of potting.

In low-country gardens of the wet south-west areas, operations cover a wide range. All general planting should be made and completed this month. Pruning and thinning out of shrubs and trees should now be attended to and new selections, indicated in the list last month, should be utilized. In the vegetable garden this is an excellent month for sowings or resowings of peas, beans, beet carrot, brinjal, knol-khol (or Khol-rabi) artichokes and the like. Tomatoes, which prefer drier conditions both for early growth and for fruiting can be left till next month, or even December.

A popular garden subject now grown with enthusiasm all over the Island is the "Shoeflower" (*Hibiscus rosa-sinensis*), because of the advent of new and striking varieties to Peradeniya a few years back. In Hawaii, where this plant grows to perfection, horticultural authorities have given much attention to raising new forms and these at the moment number over 500 in various colours and forms.

A couple of dozen of the best forms Hawaii has produced were obtained a few years ago and budded on to the common shoeflower hedge-plant at Peradeniya. The procedure, *i.e.*, budding, is very successful, but it takes six full months to produce a good budded plant. Now stocks of these new varieties have increased; the paucity of budwood, which was a retarding factor in getting these new varieties circulated in the Island is to some extent overcome. Anyone may now raise his own budded plants given the patience and technique, since budwood in fair quantity is available at Peradeniya should the grower not already have obtained plants earlier from here and grown his or her own requirements in this respect. The operation is not too difficult.

Normal cuttings of matured wood from the common hedge hibiscus and about the thickness of a lead pencil or a little more are used as rootstock. Sections of 9 in. to 10 in. in length are used and inserted in well-prepared beds to which a liberal

addition of sand is given. About 3 in. of the cutting goes in the soil and at an angle slightly varying from the vertical, and 6 in. to 7 in. left above surface of the bed. These cuttings form roots rapidly, make ready growth, and at 3 months from insertion are ready for budding.

The budding methods employed are the inverted tee as for citrus or the rectangular patch as for rubber, both being equally successful once the art of budding is attained. Cleft and side grafting is also very successful and a certain amount of time is gained by this mode of grafting but it is not recommended where budwood supplies are scanty. All operations of budding and grafting are explained and illustrated in leaflet No. 77 available from the Department of Agriculture, Peradeniya, at 10 cents per copy.

Growth above the union of bud to rootstock should be gradually reduced as the new bud shoots out and at the end of 6 months from insertion of cutting and 3 months from budding, the budded plant is fit for transfer to permanent quarters. At Peradeniya, to overcome transport difficulties, it is necessary to establish the plant in a bamboo pot, and this is done either by striking the cutting in the pot direct or lifting from the bed after a month to 5 weeks from insertion and one month or so before budding.

Colours range from light pink to deep carmine, and to those not acquainted with the fact reference can be made to a descriptive bulletin on those plants with coloured plates illustrating 16 of the best varieties, now available at Peradeniya. Certain crosses between these new varieties have been made and some very fine results attained and these will become available for distribution shortly.

Those anticipating opening up or extending their fruit areas should have all preparation completed and plants put in by the end of this month. The main fruits would consist of citrus, mango, jak, pineapple, papaw and plantains but useful fruit to establish in the orchard also include mangosteen, durian, rambutan, sapodilla, soursop, custard apple, avocado pear, guava, Brazil cherry, loquat and Ceylon gooseberry. Up-country a selection should include tree-tomato, cherrimoyer, China guava, persimmon, passion fruit, strawberry, Cape gooseberry, mountain papaw, peach, fig and the red-heart and golden-drop plum. Literature is available on planting distances and general care, with selection of varieties of all these fruits, if application is made to Peradeniya.

Birds, though destructive in the fruiting season of soft fruits, are on the whole of considerable benefit to the gardener. Certain species are of direct benefit in that they destroy caterpillars, grubs, borers and the like, and it is wise to cater for

bird life to some extent to reduce depredations on fruit trees proper. The planting here and there in spare spaces of such trees as the wild guava and species of Ficus or wild fig, assists in this respect. Of particular merit, however, is a very valuable fruit and foliage tree fairly recently introduced and now becoming common, and known as the Jam fruit tree (*Muntingea calabura*).

This tree is recommended as a boundary to any garden, orchard or small fruit plot in that its growth is remarkably rapid, it has a full umbrella habit of growth, is most ornamental and is continually in flower and fruit. It is a small to medium size tree, of shallow and small root system, will grow in wet and dry zones, and its fruit is useful to man and bird. The berries are useful for tarts and also for jams but the primary use of the trees would be, of course, for birds.

November might be considered the month for garden consolidation. Weather is usually wet and cool. If not already done, all planting operations should be completed this month. Any gaps or sick plants in last month's planting out should be replaced early, the soil kept stirred up and friable and all incentive possible to free growth given to all plants in beds and borders.

Much can be done in laying out or renewal of lawn areas along this time of the year. Numerous requests are received periodically on this subject and the methods to employ in making or maintaining a good lawn might well be dealt with now.

Dealing first with lawn making, the first essential is that the area to be treated should be properly prepared by thoroughly digging, removal of coarse stones, roots and other impedimenta and the surface uniformly levelled and rolled smooth. Drainage is very essential or sourness and tufty coarse grass is the result eventually. In very light and sandy soils the turf is liable also to become patchy, in dry weather. Where soil is heavy, therefore, a good layer of sand or sandy soil is required for incorporation in the top layer of the proposed lawn area; where soil is light some form of manures such as cattle manure leaf-mould and the like with a layer of soil of fairly heavy clayey texture forked in the surface or spread on a layer.

Lawn raising from seed is not recommended under our extreme conditions except for elevations of some height where conditions are cool and uniformly moist. In mid and low country the soil after seed planting has to be frequently watered or the delicate seed is soon burned up. The soil, being necessarily of fine texture for such work, is liable by reason of these frequent waterings to cake and a hard pan formed which

injures germination tremendously, and weed growth too is troublesome to control in such areas. Some seed will come through, of course, but a percentage only sufficient to produce a very thin and poor cover.

A common method here is to cut large sods roughly 8 in. to 10 in. in diameter with a spade or mammoty from some close-cropped pasture land or other, and plant in the new area a foot or so apart. It is not too satisfactory, however, and by far the best method is turf dibbling. Large areas can by this method be dealt with very economically, and it is easier to obtain and increase the one or two types of grass particularly desired and considered best for the locality. By this method small root sections of selected grass are dibbled in at distances of 4 in. to 6 in. apart over the prepared area. As the area is dibbled the surface soil should be levelled out to leave a smooth surface. Subsequent care involves periodical weeding and as the grass roots grow these should first be cut with a pair of garden shears and not by the mower. Light rollings now and again help matters and after 8 to 10 weeks from planting the mowing machine can be put on for the initial mow. In 3 months or a little later, according to favourable weather conditions or otherwise, a very fine sward or turf can be formed.

Good types of grass for lawns in general are the Bermuda grass (*Cynodon dactylon*) known also in India as the "Doob", the "Carpet grass" of America (*Axonopis compressus*) and our local "Blue grass" (*Panicum longiflorum*). There are others such as *Paspalum sanguinale*, the clover like perennial (*Desmodium triflorum*), and the local *Tuttiri* or "Love grass" which resists, drought well, forms excellent turfs in the moist low country and semi-dry areas in spite of the objection when allowed to seed of its sharp-hooked spines.

Existing lawns needing renovation can be improved by means of a top dressing of well-decayed cattle manure broken up small or sifted, and mixed well with earth of good humus content, some bone dust and a proportion of sand. The best way to apply is to thrust a 4-pronged garden fork vertically into the turf and work to and fro leaving holes or cavities roughly the diameter of the prongs and 3 to 4 inches deep. The holes are made at 3 to 4 inches apart over the whole surface after which the dressing is carefully spread over the surface and raked in. By watering, or in the first rains, the surface sifted soil is washed into all the crevices, the dressing thereby penetrating down to the roots of the grasses, rather than acting merely as a surface dressing. One cart load of sifted dressing should suffice for 3 squares of land, *i.e.*, 300 square feet in area. Regular mowing and rolling are essentials of a good lawn area and the amazing fine swards of turf to be seen in old-established

gardens in Europe are a source of envy to the resident in the tropics. The lawns in such gardens can well be termed the true focus of the picture.

Such are not acquired however by mere mowing and rolling. Nitrogen and phosphates are a requisite of the really good lawn and if we take away the store of nitrogen and phosphorus in the mowings and put nothing back, the soil soon becomes impoverished whereby weed growth which thrives on a lower level of subsistence will oust the lawn grasses.

Occasional dressings as mentioned above are very necessary but where organic manure is difficult to obtain inorganics in the form of superphosphates and nitrate of soda very materially help in lawn maintenance. Dressings of such a mixture should be given at roughly 4 ounces to the square yard .

Lime is very essential to most lawns though not generally recognized, and dressings should occasionally be given, preferably before the monsoon rains set in. Half a pound per square yard, which works out at roughly 2 tons per acre, is a satisfactory dressing and should be applied every 2 or 3 years.

This liming function is not given the prominence it deserves in gardening operations, especially as Ceylon soils are normally deficient in lime. Lime in some form is necessary in all garden soils and may be said to be the base of all fertility. No matter how rich a soil may be in other constituents, unless lime is also present it is impossible to grow good produce.

Many vegetable gardens Up-country are limed periodically, but this attention is seldom given to other parts of the garden or to Low-country gardens in general. Except where plants which resent lime are grown, and these are very few indeed, all gardens should be dressed with lime at least once every 4 years. For normal purposes 6 to 8 ounces per square yard is a good average quantity of lime to apply, the heavier soils requiring the heavier dressing.

On very light soils lime is best applied in the form of chalk, as ordinary lime is apt to destroy the small quantity of humus present, from 1 to 2 pounds per square yard being necessary. Lime in addition to making the soil more fertile checks the ravages of insect pests and encourages the development of the useful soil bacteria.

If not already attended to, pruning and thinning out of shrubs, trees and such like should now be completed. Dahlias Up-country should now have finished flowering and the bulbs can be lifted about two weeks after cutting down the plants, and stored in a dry shed for planting at the end of December.

SELECTED ARTICLES

FARM DRAINAGEWAYS AND OUTLETS[1]*

PROPER disposal of surface run-off is a major problem in the development of satisfactory farm conservation plans. It is poor planning to expend funds and effort in securing proper land use with contour cultivation, conservation rotations, strip cropping or terraces to conserve the soil on sloping fields, and at the same time to neglect the drainageways which convey concentrated run-off. Ultimate gullying in neglected drainageways will eventually undermine and destroy the soil conservation measures on the adjacent slopes as well as any benefits derived from them. Supporting field examples can be pointed out everywhere. In the South, where terracing with contour tillage has been widely used for many years, inadequate outlets frequently lead to destruction of the terraces and accelerated gullying often to such extent that abandonment of entire fields became necessary. In other sections gullying branching out from unprotected drainageways has destroyed many fields where rotations, contour cultivation, and strip cropping were practised.

The location of drainageways and outlets also has a marked effect on the ultimate success of the entire farm conservation plan. Recent field observations directed attention to farms where complete soil conservation practices had been installed but the entire plan failed to secure whole-hearted support of the farmer because of improper drainageway locations. Once established, the relocation of drainageways is usually a costly and discouraging undertaking. Proper drainageway locations are largely dependent upon the natural drainage pattern of the area involved. Drainageways located according to property lines, or for the primary purpose of facilitating conservation measures previously installed, often lead to costly or inconvenient farming systems.

The necessity of establishing satisfactory run-off disposal plans at the outset was not generally recognized during the first attempts to develop complete soil conservation plans for individual farms. The earlier efforts were concentrated on problems of proper land use and determination of practical types of practices to check soil losses on individual fields. It was not until many of the resulting farm plans had been established that the

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[1] The term "drainageways" refers primarily to channels of surface drainage in the upper reaches of watersheds or in unit drainage basins. "Outlet" is a more restricted term and refers only to drainageways that are provided to receive and convey the discharge from the ends of terraces.

* By C. L. Hamilton, Agricultural Engineer, Soil Conservation Service, Washington D.C., U. S. A., in *Soil Conservation*, Vol. IV., No. 7, January, 1939, page 156.

importance of over-all run-off disposal plans were fully realized. The installation of many of the plans proved to be uneconomical, while others required costly readjustments before satisfactory results could be obtained. The most disappointing experience resulted from improper location of many of the initial drainageways; their relocation, to facilitate the establishment of subsequent conservation measures on adjacent fields or farms, required extensive readjustments and expense. Even to-day some engineers and conservationists do not fully appreciate the necessity of developing adequate run-off disposal plans at the outset.

Planning Run-off Disposal Systems: There are two distinct phases in planning farm run-off disposal systems. The initial or general planning involves the selection of the number, type, and location of required drainageways, and of the installation procedure for each. The secondary or detailed planning involves the determination of capacity, design, and construction or establishment details. The former phase should be included in the development of initial farm conservation plans and the following discussion will be limited to this aspect of run-off disposal planning.

The first step in planning a farm run-off disposal system is to make a physical inspection of the farm and the adjacent areas. The main drainage features such as draws, ridges, and slopes should be noted. Their location and condition are of particular importance. Field and property lines, roads, buildings, fences, &c., while of lesser importance, should also be noted. This preliminary inspection will reveal the general drainage characteristics of the area and enable a tentative selection of at least the main depressions that should be reserved for permanent drainageways. The number of lateral drainageways required will depend not only on the topographical features but also on the soil conservation practices to be used. For example, where run-off interception is to be provided by the use of terraces or diversion ditches, the retention of some of the minor depressions as permanent drainageways can often be avoided. On areas where no run-off diversion measures are used, all lateral depressions that carry any applicable amount of run-off must be reserved as drainageways. As land use and soil conservation plans are developed for the area, the field boundaries, fence lines, and meadow or pasture areas can often be adjusted so as to make it easier to establish and maintain the selected drainageways.

On areas to be terraced the problem of locating and establishing outlets is inseparably associated with planning the terrace system. The cost of terrace construction, and the ultimate success of the terraces, are dependent upon proper planning of outlets. Conversely, adjustments in the location and in the direction of the flow of terraces will often greatly facilitate outlet control. For example, changing the direction of the terrace grade near the centre of a terrace, or running the grade of alternate terraces in opposite directions, will diminish the concentration of run-off and often make it possible to distribute the run-off from a terraced field over native cover on adjoining areas. Where special outlet strips or channels are required, it is often more satisfactory to drain terraces toward the outlet channels from both sides so that each outlet channel will serve a larger area, thus reducing the number required.

It has been found necessary to plan surface drainage systems according to natural drainage units. A drainage unit comprises a natural depression or drainageway together with the land that drains toward it. This means that the initial surface drainage plans for all fields or farms within the drainage unit should be developed concurrently, irrespective of boundary lines. Plans should provide for continuous conveyance of the run-off and economical development of the drainageway from field to field and from farm to farm until a stabilized water-course is reached. With a properly planned procedure that is in harmony with the natural drainage pattern, drainageways can usually be systematically established, if necessary, by field or farm increments so that each part can be fitted together without difficulty or expense when the final conservation job is completed for the entire drainage unit. In some areas the most effective field application of this plan may even involve the co-operative development and maintenance of certain drainageways by two or more land owners. Recent experience has shown that co-operation between landowners and highway officials, in the subsequent development of dual-purpose drainageways that carry run-off from the highway right-of-way as well as from the adjacent farm land is often advantageous.

Classification of Drainageways and Outlets.

Drainageways	Natural		Constructed		
	Vegetated	Unvegetated	Vegetated	Mechanical	Miscellaneous
Draws (unterraced areas)	Grassed [1]	Rock	Meadow strip	Drop check	Combination
	Wooded		Pasture strip	Lined [2]	Unlined
Individual terrace outlet	Grassed slope [1]	Rock slope	Grassed slope [1]	Drop check	Absorptive
	Wooded slope		Wooded slope	Lined [2]	Accumulative
Collective terrace outlet	Grassed [1]	Rock	Meadow or pasture strip	Drop check	Combination
	Wooded		Field or roadside channel	Lined [2]	Unlined

[1] Often referred to as meadow or pasture depending upon how the forage is utilized.
[2] Discharge velocities are usually higher in lined channels and the channels are sometimes referred to as high velocity.

Selection of Type : Natural drainageways that are still protected by native vegetation should always be given first consideration. They should be protected and utilized to the fullest extent possible because it is usually difficult to re-establish or duplicate these original drainageways and, at best, it is frequently a costly procedure. Natural drainageways that have been only partially damaged by overgrazing, or by the development of a few breaks in the original cover, can usually be repaired or restored. The sooner this is done the more successful it will be and the smaller will be the expenditure of labour and materials required.

Since much of the native covering has been ploughed up or destroyed and so many drainageways have been severely damaged by gullying, it is necessary to establish many new ones or rebuild old ones. In the re-establishment of these drainageways the results are usually most satisfactory where the natural features are reproduced as nearly as possible. There are some areas, however, where the soil and climatic conditions or artificial conditions introduced with agricultural practices may justify or even necessitate some modification of nature's procedure. It must be recognized that problems of drainageway development are neither equal in importance nor uniform in character in the various climatic, geographic, soil, and type-of-farming regions.

Due to the diversity of conditions encountered, it is obviously impossible to select a standard method of drainageway protection and attempt to apply it universally. The only satisfactory procedure is to determine in what order the various types of drainageways should be considered and what form of each type is best adapted locally and can be economically established and maintained. From the standpoints of economy and practicability, including ease of establishment, the various types of drainageways should be considered in the following order :

(1) Vegetated individual outlets (terraced areas only).
2. Meadow or pasture strips.
3. Vegetated channels.
4. Mechanical protection.

In field practice the natural conditions encountered will often prohibit the use of certain types, but the types should usually be given consideration in the order named and no method should be discarded as impractical until thorough investigation has proved it to be so.

Pretreatment of Drainageways and Outlets : In most areas it has been found not only hazardous but also expensive to attempt to establish grassed drainageways or outlets at the same time that they are being used for the disposal of run-off. This is particularly true on areas where terraces concentrate additional run-off in the drainageways. Newly prepared seedbeds, seeds, fertilizers, and young plants offer little resistance to erosion and are frequently washed out unless special precautions are followed. Solid or strip sodding, when properly anchored, will sometimes carry run-off without harmful results immediately after it has been placed. This, however, is a relatively costly method of establishing vegetated drainageways, and the expense retards extensive use of vegetal protection. It is sometimes even difficult to anchor newly placed sod in certain channels in such a way that it will not be damaged by heavy run-off. Damage from run-off is more acute in the establishment of vegetation in outlet channels than in wide grassed drainageways because of the higher velocities produced in the smaller channels. There are several possible methods that can be used to save expense, eliminate the run-off hazards, and make the development of seeded drainageways more dependable and practical.

On areas to be terraced one of the most promising plans is the establishment of outlets before the terraces are constructed. A few years ago a general

feeling prevailed that the application of this practice would prove impractical under field conditions. Recent observations and field tests, however, have shown that the establishment of outlets in advance of terracing can, with proper planning, not only be practical but distinctly advantageous in many areas and that it should be given first consideration in the development of any extensive terracing program. As a result of this practice, some Soil Conservation Service project engineers report that C. C. C. camps have been able to accomplish approximately five times as much outlet work as otherwise. They have also been able to establish economical outlet protection where other methods have proved too costly, and the greater accomplishments have resulted in extending the work to many more farms.

The success of this method has been made possible by the complete farm run-off disposal plans which include the number, location, type, and order of drainageway development as a definite part of preliminary farm conservation planning. The location of all terraces to be used, and their direction of drainage, are also specified in the run-off disposal plans. Where this practice is not followed, it is difficult effectively to establish outlets in advance of terrace construction. It is important that the outlets be located and constructed so as to facilitate later terrace construction. Otherwise, they cannot be efficiently used when the final conservation measures are installed and they will represent wasted efforts and expenditures.

For the most effective use of pre-established outlets, the order of terrace construction is largely determined by the order in which established outlets can be made available. Terrace construction is arranged so that the areas for which natural outlets are available, or for which outlet channels require solid sodding or mechanical protection, can be terraced the first year while the vegetation is becoming established in other outlets. Outlets must be established as early as possible in order that the final terrace construction work will not be delayed. The change from the common practice of treating outlets following terracing to the new practice of establishing outlets in advance of terracing will involve a transition period in any terracing program. During this period it may be advisable to establish part of the outlets after terracing so that the terrace construction work may be continued without undue interruption. The length of the transition period will largely depend upon the additional effort directed to outlet construction or the rate at which outlet construction can be temporarily accelerated. The normal rate of outlet construction can be resumed once the outlets are well in advance of terrace construction. The shorter the transition period can be made, the sooner the full benefits of pre-established outlets can be achieved.

Where grassed drainageways are to be established by seeding on unterraced areas or on terraced areas where established outlets are not available, the use of some form of temporary run-off protection is often advantageous. Even with pre-establishment of outlets on areas to be terraced it is often necessary to provide some additional run-off protection during the period in which the grasses are becoming established. In the South where Bermuda grass is commonly used for drainageway protection, the problem seems to be somewhat less acute. Here the Bermuda grass is usually established from

rootstalks and stolons by spot, spring, or broadcast sodding. During the initial stages, however, even this procedure is often benefited by some form of temporary run-off protection.

The practice of diverting the run-off, by means of temporary dikes or ditches, until the vegetation becomes established in the permanent drainageway is often used. The use of a quick-growing annual crop, to stabilize the drainageway before seeding the grasses, is sometimes advisable. Small grains or Sudan grass, domestic ryegrass and similar crops may be seeded in the spring to hold the soil effectively and produce a residue in which to seed the grasses the following fall. Nurse crops may also be seeded with the grasses to afford quick protection, but care must be exercised not to seed too lavishly. Where practical, such run-off retention measures as contour ridging, furrowing, listing, and subsoiling on the contributing watershed, may sufficiently reduce the run-off temporarily to assure satisfactory establishment of drainageway vegetation. On some areas where pre-established outlets were not available, it has been found that subsoiling only the terrace channels and outlets, to a depth of about 18 inches, reduced the run-off sufficiently during the following year to permit the establishment of satisfactory vegetal protection in the outlets.

Providing new grass seedings with some form of surface protection has also facilitated the establishment of drainageway vegetation in some sections. Surface mulching not only protects newly prepared seedbeds, seed, and small plants from run-off and hard rains, but it conserves moisture and produces a surface condition that encourages the germination and growth of small grass seeds. The mulch can be produced by properly anchoring a thin but continuous layer of straw, corn fodder, old hay, or fine brush over the entire seeded area. Loosely woven burlap tightly drawn and staked to hold it in place, provides good surface protection. While this treatment is more expensive, it may frequently be used advantageously on small areas or at vulnerable points in larger areas. Regardless of which method of run-off protection is used, it is essential that adequate seedbed tilth and fertilization be provided, and that suitable seeding rates and mixtures be used for satisfactory results. Even with run-off protection, it cannot be expected that grasses and legumes will thrive well where topsoil and necessary fertility are lacking.

ROOTS*

THE study of the root systems of crops grown in the tropics and sub-tropics is a branch of agricultural research which has not received the attention which it deserves ; in fact, so little information has been published on the subject that one is forced to fall back on inferences rather than to depend on concrete knowledge. This study is more important in the tropics than in temperate regions, because the range of environment is so much greater, and there is no doubt that environment has a considerable influence on the root development and root system of any particular species, or of any cultivated race of a species. For example, the work which has been done at East Malling in examining the root systems of different races of fruit stocks has shown clearly that these vary both with the stock and with the type of soil on which they are grown.

A striking example of the influence of environment on the root system of a species is the case of the Neem tree (*Azadirachta indica*), which has been introduced into the Gold Coast within the last twenty years. Its native habitat is in India, where it is generally found growing in open country in the drier parts of the country. It is not exacting in the type of soil on which it grows except that it is not seen on deep black cotton soils. Under Indian conditions the tree makes a strong tap root which penetrates vertically into the ground for a considerable depth, and it shows little tendency to form strong branch roots near the surface. In the Gold Coast the tree is now a common feature in roadside, town and village planting, and it is not unusual to see trees where the root system has been exposed by erosion. The most striking feature shown is the tangled mass of thick surface branch roots extending laterally quite close to what must have at one time been the surface of the ground. In fact, one may say that all the common exotic species of trees which are grown in West Africa develop under that environment a shallow root system. This adaptation of the root system to suit a particular environment may explain why it is that trees found useful in one country as shade for a particular plantation crop may prove quite unsuitable or even harmful in another environment In some of the West Indian Islands one cannot help admiring the magnificent specimens of raintree (*Pithecolobium Saman*) which are seen as avenue and savannah trees. In popular accounts of this tree one reads how it closes its leaves when it rains and thus allows the rain to fall on the ground beneath its shade. Certainly in this environment it does not seem to do harm to surrounding vegetation. The same species grown in the drier parts of Peninsular India is, however, a menace to arable

* By H. C. Sampson, C.I.E., in *The Empire Cotton Growing Review*.—Volume XVI—No. 3, July, 1939.

agriculture, as there it develops a wide-spreading surface root system which robs the soil of moisture sometimes for a distance of sixty to seventy yards. This makes it impossible to grow rain-fed crops on the area of its root spread, and it is a common complaint of villagers that the tree when planted as a road avenue renders the adjacent land useless for agriculture.

Apparently little has been done to study the root systems of plantation crops in the tropics. If it has, very little literature is available on the subject, and such information as exists deals only with particular environments. The matter is of great importance, especially in the case of plantation crops which are interplanted with shade trees and cover crops; for it seems essential to appreciate what amount of root competition exists between the shade tree and the crop. Of course in some soils this is more important than in others. In heavy soils retentive of moisture and where the rainfall is heavy, such competition may be of actual value, because the roots of the shade tree may assist in draining the soil, thus providing a suitable environment for the roots of the crop. This may explain why it is that shade trees in cacao are advocated in Trinidad, whereas in the nearby island of Grenada it is grown without shade.

Information regarding the root systems of plantation crops is often required when laying out experimental plots. A knowledge of the root-spread of individual trees, for example, is essential when laying out manurial experiments, in order to decide how many guard rows are necessary between plots. It was a matter of surprise to be told the other day that, when the root system of a mature oil palm was exposed, several of the roots extended over 100 feet, while the longest measured 127 feet. This was in a sandy soil with a fairly high water-table, and of course may not represent the root-spread of a palm grown on a heavier, deeper and more fertile soil.

Various theories have been expressed on the action of the bush fallow, which is common throughout tropical Africa, where shifting cultivation is the rule, in restoring fertility to the land. The one which seems most important is the deeper root system of the natural tree vegetation which brings up from deeper levels to the surface soil additional amounts of plant food. A striking example of an artificial bush fallow is found in the densely populated region of the Eastern Province of Nigeria. Among the Ibo people, who inhabit the deep sandy soil country of the palm belt, each household has its compound land, but there is also an expanse of communal land. Among many of the clans, however, it is the custom that if one of its members plants up a portion of the common land with a small rosaceous tree called *Acioa Barteri*, he is allowed to crop that area for his own use. An opportunity was given to see the root system of this tree in an area where gully erosion was severe. The gully had been checked by a planted patch of this tree, and the roots of one or two were exposed at the edge of the gully. The tap root went vertically down for a great distance, and there is little doubt it is this deep root system that has established the reputation of this tree for restoring fertility to the surface soil.

In the case of arable tropical and sub-tropical crops little information is available. Weaver has described the root systems of several sub-tropical crops which are grown in the United States, but it is felt that much more local research is necessary to gain knowledge regarding particular environments and particular races of cultivated crops.

The monocotyledons include all the cereal crops as well as such crops as onions, ginger, &c. The peculiarity of all such crops is that they do not form a tap root. Their roots are more or less ephemeral and if damaged they die, but can be rapidly replaced by freshly formed roots. All cereal crops are for this reason capable of being transplanted, and in some cases this is the normal agricultural practice, the seedlings being raised in a seed-bed and subsequently pulled out and transplanted. Swamp rice is generally grown in this way, at any rate in the more developed rice-growing areas. The seedlings are pulled out when they have reached a certain age and most of the roots formed in the seed-bed are broken. They are further damaged by beating the butts of the bundles of seedlings against a stake stuck in the ground. In some places the seedlings, which are tied in bundles, are stacked in small heaps in the field with all the roots facing outwards, and they are left in this way for two or three days for the roots to wither. Thus the transplanted crop has to start and make an entirely new root system.

The sorghum crop in India is considered to be the most drought-resistant of all cereals, and one presumes therefore that it has a deeper root system than other grain crops. There is, however, a considerable difference in this respect between varieties. One variety known to the writer, it is claimed, can mature its crop provided there is sufficient moisture in the ground for the crop to germinate and form a braird. For the rest of its moisture requirements it is dependent on dew and on moisture in the deeper soil. The question of drought resistance in West Africa is not so clear, because, though there are numerous varieties, they all appear to be long-duration ones occupying the ground for six to seven months, while in India the time of maturity is considerably less than this, and there are also short-duration varieties to suit districts having a short rainy season. The root systems, however, of the Indian and the West African varieties appear to be different, though this may be due to environment, since the rains are generally heavier in West Africa and the soils as a rule have a lower pH value. Local agricultural practice in the black cotton soils of India spaces the plants about 6 inches apart in rows about 14 inches apart. In West Africa the crop is grown on ridges 3 to 3½ feet wide, and the plants are spaced about 1½ feet apart in the row. Thus in West Africa each plant has nearly ten times the surface area that the plants have in India. This certainly seems to point to a difference in the root systems of the cultivated races of sorghums in these two regions.

In the drier parts of West Africa, where the rainfall is less and the rainy season shorter, the grain Pennisetums form the most important cereal crop, whereas in India these are not considered to be as drought-resistant as sorghum. This again may point to a difference in the root system, though it must be remembered that many of the early sown West African Pennisetums are comparatively short-duration crops.

In the case of sugar-cane, both Venkataraman and the workers at the West Indian Sugar-cane Station at Barbados have shown that there exist marked differences in the root system of different seedling varieties of sugar-cane, and it is on such differences that new varieties are selected for trial in other environments. These differences in seedling cane varieties are, however, on rather a different footing from races of cereals owing to the complex hybrid origin of the present-day seedling canes.

Apart from cultivated grass crops, recent work in Uganda has shown the value of a grass fallow where elephant grass (*Pennisetum purpureum*) is deliberately planted prior to allowing the land to go out of cultivation. It is claimed that this not only restores the texture of the soil but also its fertility, and one wonders how deep the roots of this grass penetrate to bring up from below fresh supplies of plant food. In Northern Nigeria experiments of a similar nature are being made with *Andropogan gayanus*, which, judging by the way the grass can remain green in the dry season, has, one suspects, a deep root system, thus enabling it to restore fertility to the surface soil.

The principal dicotyledonous crops of the tropics belong to the family of the Leguminosæ. The value of such crops in mixed cropping and in rotations has often been stressed on account of their being able to fix atmospheric nitrogen with the aid of symbiotic bacteria living in their roots. With few exceptions tropical pulse crops are grown as mixed crops. Recent work in this country has shown, in the case of pastures, that the grasses among which legumes are grown can make use of the nitrogen from the roots of the legumes, and it is probable that tropical cereals, among which pulses are grown, can do likewise. It is not clear whether, in the tropics, the nitrogen fixed by a leguminous crop in one season will remain available in the soil for the benefit of cereal and other crops of the next season. Experiments conducted by the Nigerian Department of Agriculture where *Mucuna aterrima* has been grown as a green manure show that there is no appreciable difference in the yield of the succeeding maize crop on plots where the Mucuna crop has been ploughed in and on plots where this has been burnt on the ground. One imagines, therefore, that value of the green manure crop largely lies in the fact that it has brought up from below supplies of mineral plant food, which are thus available for the succeeding crop. This is partly borne out by the fact that the pH of the plots where the Mucuna was burnt is higher than that of the plots where it was turned in. The fact that Mucuna has been most successful in areas where the lateritic subsoil is fairly near the surface suggests that its root system is comparatively shallow. In Northern Nigeria experiments are being carried out in restoring fertility with pigeon pea (*Cajanus Cajan*) grown as a biennial. The fact that the plant can survive through the intensely dry season suggests that it has a deep root system. Ducker, in Nyasaland, states that the roots of the pigeon pea will penetrate a lateritic pan. In the Sudan several leguminous crops have been tried as rotation crops for cotton, and *Dolichos Lablab*, agriculturally, has been found to be most suitable, though, owing to its harbouring pests which damage cotton, its use has had to be restricted. This suggests that its roots can tolerate, even if they cannot penetrate, the alkaline sub-soil. Another leguminous plant whose roots can penetrate an alkaline pan is *Sesbania aculeata*, and possibly other species of Sesbania may behave in the same way.

The groundnut is a legume which is generally grown as a pure crop, though sometimes it is interplanted among cereals. It is extremely drought-resistant, remaining green and fresh till it commences to ripen its pods. It is a crop suited to lighter classes of land, and its drought-resistant qualities have made it a valuable asset to the light red soil districts of tropical India. On such soils it is generally considered an exhaustive crop, and yields decrease rapidly after three or four years' cropping unless the land is manured. In West Africa the crop has been extensively grown for many years, and recently it has been reported that the older groundnut areas are not giving the yields that they formerly did. Considering that manuring is hardly known in West Africa, it is rather surprising that the land has not shown signs of exhaustion before this, and one can only suggest that this is due to the type of subsoil commonly found and the depth to which the roots penetrate. The red soils of India generally lie directly on the parent rock and thus have no reserves on which to draw, while in West Africa a lateritic sub-soil usually occurs.

The root system of Asiatic cottons is quite different from that of the Upland cotton of the New World. The former are much more slender and penetrate much more deeply into the soil, and the tap roots of seedlings which have made only one leaf have been traced to a depth of 18 inches in black cotton soils. It is possibly because of this deeper and therefore more drought-resistant root system that in French West Africa Indian cottons have been introduced into the dry north as a rain-fed crop. The variety is known as Budi and is stated to be a cross between two Indian cottons—Karunganni of the Tinnevelly district and the Garo Hills cotton. But even the Upland cotton has a much deeper root system than some other crops, and in Nyasaland it is generally stated that tobacco always does well after a cotton crop, presumably because the latter has replenished the supplies of mineral plant food near the surface.

It is unfortunate that there has been several years of low prices for tropical primary products ; for at such times agricultural departments are expected to produce quick results, and no one can say that the study of root systems is not a tedious and often an expensive business. It is hoped, therefore, that when and if the prices of primary products improve more attention may be given to the study of the root systems of crops in the colonies.

MINUTES, CONFERENCES, &c.

DRAFT MINUTES OF THE FORTY-EIGHTH MEETING OF THE RUBBER RESEARCH BOARD HELD AT DARTONFIELD ESTATE, AGALAWATTA, AT 10 A.M. ON WEDNESDAY, JUNE 21, 1939

Present.—Mr. E. Rodrigo, C.C.S. (in the Chair); Mr. T. Amarasuriya; Mr. C. H. Collins, C.C.S. (Deputy Financial Secretary); Mr. I. L. Cameron; Mr. L. B. de Mel, J.P., U.P.M.; Mr. W. P. H. Dias, J.P.; Mr. T. C. A. de Soysa; Mr. G. E. de Silva, M.S.C.; Mr. A. W. Harrison; Mr. R. C. Kannangara, M.S.C.; Mr. J. C. Kelly; Mr. L. E. Russell; Mr. B. M. Selwyn; Mr. E. W. Whitelaw.

Mr. T. E. H. O'Brien, Director, was present by invitation.

Apologies for absence were received from Col. T. G. Jayewardene, V.D.; Mr. F. A. Obeyesekere; and Mr. E. C. Villiers, M.S.C.

1. MINUTES

Minutes of the meeting held on March 15, 1939, were confirmed and signed by the Chairman.

2. BOARD

1. The Chairman reported the following changes in the membership of the Board since the last meeting:—

(*a*) Mr. C. A. Pereira had resigned with effect from April 7, 1939, and Mr. W. P. H. Dias had been nominated in his place from June 9, 1939.

(*b*) Messrs. T. Amarasuriya and T. C. A. de Soysa had been nominated to represent the Low-Country Products Association with effect from May 18, 1939, in place of Messrs. L. M. M. Dias and J. L. D. Peiris respectively whose periods of membership had expired.

(*c*) Mr. N. D. S. Silva had been nominated to represent the Low-Country Products Association with effect from June 26, 1939, in place of Col. T. G. Jayewardene whose period of membership expires on that date.

(*d*) Mr. L. E. Russell had been nominated to act for Mr. F. H. Griffith during the latter's absence from the Island with effect from April 1, 1939.

(*e*) Mr. A. W. Harrison had been nominated to act for Mr. L. P. Gapp during the latter's absence from the Island with effect from April 1, 1939.

(*f*) Mr. R. C. Kannangara, M.S.C., had been renominated for a further period of 3 years from June 26, 1939.

A vote of appreciation of the services of the retiring members was recorded and the new members were welcomed to the Board by the Chairman. Referring to Mr. C. A. Pereira the Chairman said that he had been a member of the Board since its inception and had now retired owing to ill-health.

2. *Visit of the Director, Rubber Research Institute of Malaya.*—Reported that Mr. H. J. Page, Director, Rubber Research Institute of Malaya would be

on a visit to the Rubber Research Scheme from July 2 to July 6, 1939. Decided to invite Mr. Page to meet the Board on July 3 at an adjourned session of the present meeting.

3. ACCOUNTS

(*a*) *Statement of Receipts and Payments of the Board for the quarter ended March 31, 1939*—was approved.

(*b*) *Dartonfield and Nivitigalakele accounts* for January and February, 1939, were tabled.

(*c*) *Identification of clones on estates.*—A statement was presented showing the receipts and payments in connection with the identification of clones on estates by the officers loaned by the Rubber Research Institute of Malaya. Decided that the credit balance of Rs. 643·63 be credited to revenue to cover the overhead charges of the work.

(*d*) *Supplementary votes.*—The following supplementary votes were approved :—

	Rs.	c.
Salaries of junior scientific staff	616	0
Fire Insurance	125	0

(*e*) *Fixed deposits.*—Reported that :—

(1) A fixed deposit of Rs. 50,000 which matured on March 20, 1939, had been transferred to current account.

(2) A fixed deposit of Rs. 30,000 had matured on April 27, 1939. Rs. 15,000 had been re-deposited and the balance had been transferred to current account.

(*f*) *Insurance against liability for accidents.*—A memorandum which had previously been circulated to members was considered. Decided to insure against liability in respect of accidents to employees not already covered under the terms of the Workmen's Compensation Ordinance.

4. STAFF

(*a*) *Terms of service for locally recruited officers.*—Consideration was given to the report of a Committee appointed at the meeting held on March 15, 1939. The report was accepted subject to minor modifications.

(*b*) *Changes in junior staff.*—Reported :—

(1) Resignation of Mr. H. J. Fernando, Budding Instructor, and appointment of Mr. W. F. Fernando in his place.

(2) Appointment of Mr. V. K. Viswanathan as Laboratory Assistant in the Chemical Department.

(*c*) *Rubber Conference Committee.*—Reported the appointment of Messrs. T. E. H. O'Brien and R. K. S. Murray to serve on the Rubber Conference Committee of the Planters' Association of Ceylon.

(*d*) *Rubber Advisory Board.*—Reported the appointment of Mr. T. E. H. O'Brien to act on the Rubber Advisory Board during the absence of Mr. F. H. Griffith from the Island.

(*e*) *Mr. R. K. S. Murray.*—An application from Mr. R. K. S. Murray for 3 months' sick leave from July 6 was considered and approved. Decided that Mr. Murray should take the opportunity of attending the Imperial Mycological Conference from September 18 to 23, 1939.

5. EMPLOYMENT OF DAILY-PAID NON-CEYLONESE LABOUR

Consideration was given to the question whether action should be taken on the same lines as that taken by Government in regard to the employment of Non-Ceylonese daily-paid labour. After discussion it was agreed that no steps be taken to discharge Non-Ceylonese labour but that as many Ceylonese be employed in the future as is practicable. It was noted with appreciation that 50 per cent. of the labour force and 64 per cent. of the tappers at Dartonfield Estate were Ceylonese.

6. LONDON ADVISORY COMMITTEE FOR RUBBER RESEARCH (CEYLON AND MALAYA)

Minutes of meetings of the London Advisory Committee for Rubber Research (Ceylon and Malaya) and the Technical Sub-Committee held on January 27, 1939, were considered and adopted.

7. EXPERIMENTAL COMMITTEE

(*a*) *Membership.*—The following appointments were made :—

Mr. W. P. H. Dias to serve in place of Col. T. G. Jayewardene.

Mr. L. E. Russell to act for Mr. F. H. Griffith.

(*b*) Minutes of a meeting of the Committee held on May 6, 1939, were considered.

1. *Bungalow for Geneticist.*—A recommendation to provide a bungalow for the Geneticist was approved and the Director was authorized to make the necessary provision in the estimates for 1940.

2. *Report of Consulting Engineer.*—The report of the Consulting Engineer was adopted and it was noted that the minor defects mentioned in the report had been adjusted. Decided to purchase a megohmmeter at a cost of Rs. 325.

3. *Preparation of concentrated latex.*—Decided that the sale of concentrated latex be continued in order to acquire further experience of its preparation on a commercial scale and to foster a demand for the product from the Indian market. Agreed that a short memorandum on the preparation of concentrated latex should be published in the Quarterly Circular.

4. *Oidium leaf disease.*—The Chairman stated that recommendations in regard to further work on Oidium leaf disease had been made by the Technical Sub-committee of the London Advisory Committee for Rubber Research (Ceylon and Malaya) at the meeting held on January 27, 1939. The proposals had been considered by the Experimental Committee and the discussion was fully recorded in the minutes. It had been decided that the question of undertaking a systematic study of the histology of the disease should be left to the Board for consideration.

After a general discussion, in the course of which Mr. R. K. S. Murray, Botanist and Mycologist, placed his views before the meeting, a decision was reached, in principle, in favour of the appointment of a whole time research officer for

work on Oidium. It was, however, noted that recurrent expenditure could not safely be increased while income remained at its present level. It was agreed that the subject should be further discussed with Mr. Page at the adjourned meeting.

(c) *Brown Bast treatment and yield recording at Dartonfield.*—Approval was given to proposals for demonstrating methods of brown bast treatment and for recording the yields of individual trees at Dartonfield.

(d) *Clone Trials.*—1. The Director was authorized to arrange for the exchange of planting material for experimental purposes with Research Institutes in other countries, subject to any necessary restrictions in regard to redistribution of the material.

2. Agreed that budwood from high yielding local estate trees be accepted for trial at Nivitigalakele on the same conditions as those recently approved in connection with the distribution of material of promising clones already under trial.

8. REPORTS

(a) Technical Officers' reports for 1st quarter, 1939, were considered and adopted.

(b) Approval was given for the exchange of progress reports with the British Rubber Producers' Research Association.

9. SMALL-HOLDINGS DEPARTMENT POSTER

The design of a poster illustrating the work of the Small-holdings Department was approved and an estimate for printing accepted.

10. PUBLICATIONS

Fourth Quarterly Circular for 1938, 1st Quarterly Circular for 1939, and Leaflet No. 17 were tabled.

The meeting then adjourned until 10.30 A.M. on July 3, 1939.

Research Laboratories,
Dartonfield,
Agalawatta.

July 12, 1939.

MINUTES OF THE ADJOURNED FORTY-EIGHTH MEETING OF THE RUBBER RESEARCH BOARD HELD IN THE COMMITTEE ROOM OF THE CEYLON CHAMBER OF COMMERCE, COLOMBO, AT 10.30 A.M., ON MONDAY, JULY 3, 1939

Present.—Mr. E. Rodrigo, C.C.S. (in the Chair); Mr. T. Amarasuriya; Mr. I. L. Cameron; Mr. W. P. H. Dias, J.P.; Mr. L. B. de Mel, J.P., U.P.M.; Mr. T. C. A. de Soysa; Mr. A. W. Harrison; Mr. R. C. Kannangara, M.S.C.; Mr. J. C. Kelly; Mr. L. E. Russell; Mr. N. D. S. Silva; Mr. B. M. Selwyn.

Mr. T. E. H. O'Brien, Director; Mr. R. K. S. Murray, Botanist and Mycologist; and Mr. H. J. Page, Director of the Rubber Research Institute of Malaya were present by invitation.

Apology for absence was received from Mr. C. H. Collins (Deputy Financial Secretary).

1. DISCUSSIONS WITH MR. H. J. PAGE

Mr. H. J. Page, Director, Rubber Research Institute of Malaya, reported on the recent negotiations in London in regard to the co-ordination of the work of the British Rubber Producers' Research Association, the London Advisory Committee for Rubber Research (Ceylon and Malaya) and the Rubber Research Institute of Malaya. A short discussion followed.

The subject of future work on Oidium leaf disease was then discussed and Mr. Page also answered a number of questions on miscellaneous planting topics.

A vote of thanks to Mr. Page for attending the meeting was adopted with applause.

2. REPLACEMENT OF BOILER

Referring to the decision arrived at at the last meeting to instal a new boiler at a cost of Rs. 1,650 the Chairman reported that it had since been found that the cost would be Rs. 2,200. Agreed that the boiler be purchased and that a supplementary vote be asked for at a later meeting if required.

3. EXAMINATION OF DISEASE SPECIMENS DURING THE ABSENCE OF THE BOTANIST AND MYCOLOGIST

Decided that the Director of Agriculture be asked to authorize the Government Mycologist to examine disease specimens submitted to the Research Scheme for report during the absence of Mr. R. K. S. Murray, on leave.

The meeting terminated with votes of thanks to the chair and to the Chamber of Commerce for the use of the Committee Room.

Research Laboratories,
Dartonfield,
Agalawatta.

July 31, 1939.

REVIEW

Talks, Verses, Songs, Dialogues, Plays and Recitations on Health.—By C. W. D. Alwines.

MR. ALWINES deserves well of the country for his useful and interesting primer on "Health Talks, &c." He has spared no pains to interest his readers in its subject matter and has resorted to novel methods of presentation of his facts. Eight of the twenty chapters of the book deal with foods, particularly local foods and these are perhaps of the greatest utility to the reader as they furnish in simple and clear language the essential facts relating to correct nutrition and balanced diets. The author has drawn freely from recent authoritative publications on the nutritive values of local and Indian foods, and has thus enhanced the value of the book appreciably. The reviewer would have been pleased to see some reference to the results of the considerable amount of analytical work on local foods done in this Department, but as part, at any rate, of the data so obtained has probably been embodied in the tables furnished by the Department of Nutrition, the omission has been of no consequence. The book should find a wider circle of readers than those for whom it was primarily intended, and should be read by every housewife on whom the responsibility for framing the domestic diet ultimately devolves. It is neatly printed and well illustrated.

A. W. R. J.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED AUGUST 31, 1939

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1939	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Blackquarter	1	..	1	..	..	..
	Anthrax	12	12	10	2	..	..
	Rabies	2	..	..	..	..	2
	Rinderpest	9	..	..	2	..	7
	Piroplasmosis	4	..	..	4	..	..
	Haemorrhagic Septicaemia	3	..	3	..	..	..
Colombo Municipality	Foot-and-mouth disease	33	1	3	29	..	1
	Anthrax	1	..	1	..	..	..
	Rabies	2	..	2	..	..	..
	Piroplasmosis	6	1	1	5	..	..
Cattle Quarantine Station	Foot-and-mouth disease	2	..	..	2	..	..
	Anthrax	29	..	29	..	..	.
Central	Foot-and-mouth disease	357	183	..	182	175	..
	Anthrax	5	..	5	..	..	..
	Rabies	8	..	2	..	..	6
	Contagious mange	18	..	2	16	..	..
	Blackquarter	9	1	8	..	..	1
	Piroplasmosis	10	1	2	8	..	..
Southern	Foot-and-mouth disease	660	65	31	598	31	..
	Rabies	2	1	..	..	..	2
	Haemorrhagic Septicaemia	4	..	4	..	..	..
Northern	Foot-and-mouth disease	130	..	7	123	..	..
Eastern	Foot-and-mouth disease	5	..	..	5	..	..
	Anthrax	42	42	42	..	..	..
North-Western	Foot-and-mouth disease	122	..	3	119	.	..
	Contagious Mange	18	18	..	..	18	..
	Rabies	6	2	1	..	..	5
North-Central	Foot-and-mouth disease	1,695	29	10	1,656	29	..
	Blackquarter	27	27	27	..	..	..
Uva	Foot-and-mouth disease	101	..	4	97	..	..
Sabaragamuwa	Rabies	2	2	..	..	..	2
	Haemorrhagic Septicaemia	1	..	1	..	..	..

Department of Agriculture,
Peradeniya, September 16, 1939.

M. CRAWFORD,
Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, AUGUST, 1939

STATION	Temperature: Mean Maximum	Temperature: Difference from Average	Temperature: Mean Minimum	Temperature: Difference from Average	Humidity: Day	Humidity: Night (from Minimum)	Amount of Cloud	Rainfall: Amount	Rainfall: No of Rainy Days	Rainfall: Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	84·0	—0·7	77·3	+0·7	79	86	7·4	6·76	7	+4·12
Puttalam ..	85·9	—0·3	77·5	—0·1	75	86	6·2	0·78	5	+0·53
Mannar ..	86·9	—0·8	78·4	—0·1	74	84	8·6	0·09	1	—0·40
Jaffna ..	86·1	+0·4	79·4	+0·5	76	82	4·4	0·48	1	—0·56
Trincomalee ..	91·7	+0·2	77·4	+0·6	60	80	6·4	0·53	3	—2·98
Batticaloa ..	91·9	+1·7	75·9	-0·4	61	75	5·0	2·17	3	+0·37
Hambantota ..	87·6	+1·1	75·9	+0·1	72	86	6·0	1·51	8	+0·47
Galle ..	81·5	—1·0	77·3	+0·9	81	84	7·0	6·40	11	+1·23
Ratnapura ..	88·9	+1·9	76·7	+2·7	72	88	7·2	9·91	18	—0·69
Anuradhapura ..	88·6	—2·7	74·2	—1·1	68	90	7·0	5·62	5	+4·38
Kurunegala ..	85·1	—2·3	74·7	+0·2	72	86	6·8	9·52	12	+6·81
Kandy ..	81·8	—1·3	69·3	—0·6	74	87	8·2	9·49	16	+4·02
Badulla ..	85·5	—0·8	63·1	—1·2	53	89	4·8	1·91	7	—0·80
Diyatalawa ..	76·8	—1·4	61·2	—0·4	58	78	5·8	3·58	9	+0·54
Hakgala ..	67·6	—2·5	55·1	—2·3	80	91	5·8	6·60	11	+1·57
Nuwara Eliya ..	65·0	—1·8	53·3	—0·7	82	91	8·4	7·63	19	—0·03

The rainfall for August was above average over the greater part of the Island, the largest positive offsets ocurring in the hill-country and in the districts between the hill country and the west and south-west coasts. Slight deficits were reported from the north and east of the Island, where August averages are low. The greatest excesses were 19·19 inches at Geekiyanakanda, 17·24 inches at Etnawela, 16·13 inches at Nilloomally, while excesses of over 10 inches were also reported from Hiniduma, Vincit, Avissawella, Oonanagalla, Pathregalla, and Ruwanwella. The largest negative offsets were 2·98 inches at Trincomalee and 2·78 inches at Kanukkeni.

The highest monthly totals reported were 28·14 inches at Kenilworth, 28·05 inches at Kokkawita, 27·89 inches at Dartonfield, 26·89 inches at Geekiyanakanda, and 26·61 inches at Theydon Bois, while totals of over 25 inches were also received from Nilloomally, Luccombe, Norton Bridge, Padupola, and Watawala.

Nearly 20 stations in the north and east reported no rain at all during the month.

There were altogether 89 daily falls of 5 inches or over, of which 52 were on the 9th and 32 on the 10th. From among the stations that send rainfall figures regularly to the Observatory, the largest daily fall reported was 21·03 inches at Dartonfield on the 9th. This was said to be an underestimate, as the gauge was found to have overflowed. According to other information available this figure of 21·03 inches had been exceeded at three estates in the neighbourhood. Mamodola Estate measured 24·08 inches, Dalkeith Group 23·65 inches, and Pimbura Estate 21·99 inches The next highest daily fall was 20·15 inches at Geekiyanakanda. All these falls occurred on the 9th.

During the first three days of the month settled weather prevailed, with little or no rain. A distinct slackening of the south-westerly pressure gradient resulted in fairly widespread rain, generally light or moderate, from the 4th onwards. Thunderstorm activity was responsible for an appreciable amount of rain on the east side during this period. On the morning of the 9th, signs of a strengthening of the pressure gradient were evident, and the rainfall reported on the morning of the 10th was particularly heavy in the south-west of the Island, abnormally heavy falls, several of them over 20 inches, being registered in the Kalutara District. Severe squally conditions and thunder accompanied these falls, while two stations in that area, Millekande Estate and Tempo Estate, reported hail on the afternoon of the 9th. The rainfall continued to be moderately heavy in the south-west during the next two days, and although the pressure gradient remained appreciably steep till the end of the month, the rainfall steadily decreased and very little rain occurred during the last third of the month.

Temperatures were in general slightly below average. Humidity was on the whole below normal, while cloud amounts were irregularly distributed on either side of average. Winds were above normal strength, the general direction being south-westerly.

Besides those cases mentioned above, hailstorms were also reported from Diyatalawa on the 7th and from Polgahawela on the 10th.

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Acting Superintendent, Observatory.

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EDITORIAL

AGRICULTURAL PRODUCTS (REGULATION) ORDINANCE

IN a brief summary of one year's cost accounts of two departmental seed paddy stations, we pointed out in the last number of *The Tropical Agriculturist* that the paddy farmer who works on a basis of payment for all services turns the corner of loss and profit at the price level of Re. 1·90 per bushel of paddy *ex* farm, or of Re. 1·50 per bushel if no allowance is made for the capital outlay in the acquisition of the land. In years when the failure of the water supply does not cause a major failure of crops, paddy is in fact purchaseable in the North Central Province and other similarly situated districts at 90 cents or Re. 1 per bushel. This price effectively excludes the capitalist and the man who has a choice of occupations from the rice-growing industry. The marketed paddy comes from two sources :

(i.) The " unearned " landlord's share of the absentee owner.
(ii.) The produce of peasant agriculture.

Landlordism may be regarded as a constant factor unresponsive to market fluctuations and other similar influences. With the possible exception of a slight increase in yield that may be secured by the utilization of the cattle manure that goes to waste in the jungle and on the road-side in some parts of the dry zone, the peasant now produces paddy to the limit of his capacity with the resources at his disposal. He can enlarge the area under cultivation and obtain a higher return from that area only by the use of implements and fertilizers which he cannot afford to buy. He will never be able to provide himself with these necessary adjuncts of agriculture by the sale of his surplus produce at Re. 1 a bushel. It follows that, if the country wishes to replace a substantial part of its imports with locally-grown rice, it must stabilize the price of paddy at a level which is high enough both to attract the capitalist to the industry and to enable the peasant to provide himself with some working capital by the sale of part of his produce.

The same considerations apply to other agricultural commodities of local consumption. At current market prices it is

impossible to secure increased production. The question is often asked why the Ceylon peasant cannot produce foodstuffs for sale at the prices at which the Indian peasant places them on the Ceylon market. The basic fallacy underlying this question is the assumption that production is in itself a desirable end. On the contrary, consumption, or the maintenance of an adequate standard of living, is the object of all production, and it is more relevant to ask whether the Indian peasant producing for export at the prices ruling in Ceylon achieves a higher standard of living than his brother in Ceylon. Those who have lived or travelled in India give an unequivocal answer to this question in favour of the Ceylonese standard.

It has been recognized for some time by those who are interested in what may be called consumption agriculture, as opposed to export agriculture, that all schemes for food production must be based on an assured market at a level of prices which are in considerable advance of those that rule under competitive conditions. Therefore, the proclamation of the Agricultural Products (Regulation) Ordinance with effect from the first of this month constitutes a landmark of the first importance in the agricultural development of the country. The ordinance provides for the control of the imports of specified commodities by licences issued by the Executive Committee for Agriculture and Lands. A condition of the licence would be that the importer should take over a quota of the local produce at a prescribed price—the quota naturally varying from year to year according to the volume of anticipated local production. The intervention of the war at this juncture, and of the consequent measures for the control of trade, introduces some elements of difficulty to the introduction of the quota scheme. War-time control naturally has as its object the maintenance of prices at as near the level which ruled in the normal market before the war as possible. The object of the ordinance is to raise prices to a level which the producer would regard as adequate to remunerate him for his effort. It may be that in wartime the interests of the consumer are of paramount importance and that it is inexpedient to raise prices to a level which would be satisfactory to the producer. But it would be most unwise to compromise on this issue. At the beginning, prices must be almost in the nature of a bribe to a conservative peasantry and to shy capital. The difficulty of reconciling these conflicting interests is reduced by the fact that, during the first few years when the import quota is high, a very substantial increase of the price of the local product will only slightly increase the average price of the commodity which should form the basis of the control price. It follows from these considerations that very close co-operation must be maintained between the food control service and the Ministry of Agriculture.

THE DESTRUCTIVE DISTILLATION OF COCONUT SHELLS

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WHEN wood and similar substances are heated in a closed space in the absence of air, they are decomposed with the formation of charcoal and volatile products. Coconut shells have a composition qualitatively similar to that of hard woods (Cf. Fleck, Van Beckum and Ritter, 1937 ; Child and Ramanathan, 1938).

In Ceylon, coconut shells are largely employed for the production of charcoal, export figures of this product since 1933 being as follows :—

Year.	Amount. (tons.)	Value. Rs.	Value per ton. Rs.
1933	2,019	90,541	44·85
1934	6,234	350,996	56·30
1935	7,667	365,608	47·68
1936	6,751	377,137	55·86
1937	13,455	977,708	72·66
1938	10,997	823,781	74·91

This charcoal is produced by the time-honoured method of carbonizing the shells in pits and no attempt is made to recover by-products. Roughly 20,000 shells are required to produce a ton of charcoal ; there is, in addition to the exports, a limited local consumption of charcoal for fuel, in gas engines, &c., so that it may be estimated that in 1937 and 1938, about 250 to 300 million shells each year were burned for charcoal.

Since the outbreak of war there has been experienced in Ceylon a shortage of acetic and formic acids for rubber coagulation, with inflated prices for these commodities. This may be only a temporary phase, but the question has been raised whether acetic acid could not be recovered from the by-produest of coconut shell distillation.

It is the object of the present article to review what is known of the yields and composition of the products from the dry distillation of coconut shells, and thus to provide data upon which may be based consideration of their possible economic development.

PRIMARY PRODUCTS OF DESTRUCTIVE DISTILLATION

The primary products of distillation are *charcoal*, which remains in the retort or oven in which the shells are heated; *pyroligneous liquor* and *settled tar*, which distil over and are condensed in suitable water or air cooled condensers; and *uncondensable gases.*

The course of distillation is somewhat as follows: at the commencement of heating, the first action is to dry out the contained moisture of the shells (about 9–10 per cent.) and the first distillates are mostly condensed water; thereafter the main reactions set in with the formation of large quantities of gas and the liquid distillate contains acetic acid, methyl alcohol and some tar; the reaction becomes exothermic at about 290°C, *i.e.*, continue without the necessity of external heat. When this stage is over, with continued external heating tarry matter predominates in the distillate.

Yields of Primary Products.

Several studies on shells have been reported and Table I. shows the results recorded of the yields of the primary products. Literature references to the table will be found at the end of this article. Columns 6 and 7 refer to commercial trials carried out in 1934 respectively by Messrs. H and T. Danks (Netherton), Ltd., and by Messrs. Low Temperature Carbonisation, Ltd., on behalf of Messrs. Lee Hedges & Co., Colombo, and are included by courtesy of the latter firm.

Ramachandran (1938) has described experiments on the effect of adding certain chemicals to the shells before distillation, reporting that zinc and magnesium salts gave an increased yield of pyroligneous liquor, whilst aluminium salts reduce the yield of pyroligneous liquor but slightly increase the yield of settled tar. In view of the considerable variation of the results given by different observers, these statements probably need confirmation. It is possible that shells from different sources behave differently, but it is the writer's opinion that the main causes of variation are (i.) differences in the moisture content of the shells and (ii.) lack of standardization of distillation conditions. Thus the high charcoal figures and low liquor and tar percentages reported by Georgi and Buckley (column 4) probably point to insufficient heating; the low charcoal and high tar figures of the commercial trial by Messrs. Low Temperature Carbonisation, Ltd. (column 7) indicate thorough carbonisation; whilst the figures of the writer (column 5) are known to have been due to good heating of the retort but inefficient condensation of the distillate.

In spite of this variation in the reported results, they are in sufficient accord to show what yields should be obtainable under good conditions of distillation and the general averages (excluding the extreme figures) work out approximately at :—

Charcoal	34 lb.	from 100 lb. of shells.
Pyroligneous acid	40 lb.	
Settled Tar	6 lb.	
Gas	20 lb.	

Acetic acid under good conditions should reach 12·5 per cent. in the pyroligneous liquor, or 5 per cent. of the weight of the shells. That is to say, since 250–300 million shells weigh about 36 to 45,000 tons, the equivalent of some 2,000 tons of glacial acetic acid is annually burnt off into the air in the manufacture of charcoal in Ceylon.

The annual requirements of the Ceylon rubber industry of acetic and formic acid together do not greatly exceed 500 tons.

COMPOSITION OF THE PRIMARY PRODUCTS

The distillate separates into two layers, the top known as "pyroligneous liquor" and the latter as "settled tar". The settled tar does not represent all the tarry substances present, parts of which remain in solution in the pyroligneous acid and are known as "dissolved tar".

Pyroligneous Acid (the word "pyroligneous" simply indicates "derived from wood by a process of heat"), is by no means a simple chemical substance, but a complex mixture of a large number of compounds. The actual composition varies with conditions of distillation and with the raw material used. The principal constituent is, however, acetic acid, and "pyroligneous liquor" or "pyroligneous acid" may be regarded as an impure dilute acetic acid contaminated with other compounds. It is a dark, reddish-coloured liquid with a strong, smoky smell. As will be seen from the Table, the acetic acid content may vary between about 7 and about 15 per cent. but with dry shells and satisfactory distillation at least 10 per cent. should be obtained, and if the weaker first distillates be rejected, at least 12·5 per cent.

The other constituent of importance is "wood naphtha," a mixture of methyl alcohol and acetone. The percentage has been reported as 2½–3 per cent. in the liquor, or 1–1·2 per cent. on the original shells. (Wells, 1917 ; Sudborough, 1920).

Settled Tar.—The division of constituents into those present in pyroligneous liquor and in the settled tar is, of course, only

approximate, since any of the main constituents of one may be found in small quantities in the other. The settled tar, for example, contains some acetic acid.

The tar is a very complex mixture. There is nothing like a complete analysis on record, and there is very much more variation between the tar from various sources than in the pyroligneous liquor. Thus coconut shell tar differs considerably in composition from (say) beech wood tar, and is dealt with later.

Charcoal contains the non-volatile products. It consists mainly of amorphous carbon, but retains adsorbed some of the volatile products of carbonization and also contains the inorganic (ash) constituents of the shells. A separate account of the subject of coconut shell charcoal will be given in a separate article and further details are accordingly not given here.

Gas.—The gas evolved contains mostly carbon dioxide and monoxide, but the actual composition will vary considerably with conditions of distillation. The only available report on the gas from coconut shells (column 7) gives the following details :—

Yield—5,144 cu. ft. per ton of shells (16·4 per cent.)

Calorific value—396 B.T.U./cu. ft.

Sp. gravity—0·9336.

Therms of gas per ton of shells carbonized—20·37.

COMMERCIAL UTILIZATION OF THE PRODUCTS

Coconut shells compare very favourably with most woods as raw materials for distillation, particularly in two respects. The moisture content of air-dried shells is low (not more than 10 per cent.), and the yields of acetic acid are extremely good.

Treatment of Pyroligneous Acid.—In the wood distillation industry, pyroligneous acid is usually redistilled to separate it from dissolved tar. The distilled pyroligneous acid is neutralized with lime and partially distilled to recover the "wood naphtha," the latter being then purified by suitable means. The neutralized solution remaining is evaporated to dryness leaving acetate of lime known commercially as "grey acetate."

From "grey acetate", acetic acid is obtained by treatment with sulphuric acid, and purified by suitable rectification.

The latter operations are matters of specialized technique, and it may be said at once that, in the writer's opinion, it would not be practicable to undertake them in Ceylon.

It should also be made clear at this point that it is not possible to concentrate acetic acid from dilute solutions such as pyroligneous acid by simple distillation. The boiling points of water (100°C) and of acetic acid (118°C) are fairly close together, and no constant boiling mixture are formed, as in the case of alcohol.

Numerous attempts have been made by industrial chemists for many years to concentrate acetic acid from pyroligneous acid without going through the intermediate stage of acetate of lime. Solvent extraction processes have been the most successful of these, of which, among others, are processes using ethyl ether (Brewster process), *iso* propyl ether (modified Brewster process) and wood oil (Suida process). A description of these is given by Partridge (1931).

All such processes involve specialized plant and technique. It may, therefore, be considered that the production of glacial acetic acid, or even 50 per cent. acetic acid, cannot possibly be contemplated in Ceylon at the present stage of development.

All that could be contemplated is the possible purification of pyroligneous acid to provide a reasonably pure dilute acetic acid of about 10–15 per cent. strength which would be suitable for rubber coagulation; and also, since lime is a local product, the production of a certain amount of "grey acetate." Both of these are technically possible, since they involve fairly simple plant and do not require imported chemicals. The difficulties are not technical but economic.

The writer's experiments using a pyroligneous acid of 9·33 per cent. w/v acid content (as acetic) show that, by the addition of 30 per cent. by weight of crude salt to raise the boiling point, it is possible by simple distillation to effect considerable purification and some concentration. A number of runs showed that the first 5 per cent. approximately of the distillate contained most of the "wood naphtha"; the next 50 per cent. was a colourless distillate averaging 11·1 per cent. w/v acidity as acetic.

It is still, however, by no means pure dilute acetic acid. Besides acetic acid, the redistilled liquor contained some formic acid and dissolved phenols. The former amounted to 0·43 per cent. w/v and the latter (determined by chloroform extraction) to 2·36 per cent. w/v. Furfural was detected qualitatively. The presence of formic acid would not be a disadvantage in rubber coagulation, but coagulation and vulcanization tests on rubber prepared by the use of the material are necessary to ascertain whether phenols, furfural and other compounds have any deleterious effect.

Further experiments are in progress to see whether better recovery is possible, and the Director, Rubber Research Scheme, has agreed to carry out the necessary test coagulations and vulcanizations.

Reference might be made here to the patent of E. C. R. Marks (1915) which claims " a process for coagulating latex characterized in this that the gases obtained by the destructive distillation of wood, in suitable retorts, or the like, after removal of the tar from the gases, are employed for treating the latex".

It would probably not be worth while in Ceylon attempting to recover methyl alcohol or even crude "wood naphtha". There is no local demand for the product, and the recovery is in any case more difficult in tropical than in temperate climates.

Grey Acetate.—In 1916 (Bull. Imp. Inst., *loc. cit.*), samples of grey acetate were prepared in Ceylon, and the Imperial Institute reported on them as follows :—

" It consisted of a coarse powder, pale grey in colour, and had a tarry odour. Its solution in water was of dark-brown colour.

On analysis the sample gave the following results :—

Moisture	3·50
Calcium acetate	83·60
Sulphates expressed as calcium sulphate	0·60
Carbonates expressed as calcium carbonate ..	0·08
Total ash	32·20
Matter insoluble in water	1·20
Free lime, Calcium formate, Sulphites	Nil

This sample corresponds in quality with commercial 'grey acetate of lime', which usually contains 80 per cent. of acetate of lime. The amount of tarry matter is not excessive."

At that time grey acetate had increased in price from £8 per ton in July, 1914, to £38 a ton, and inquiries were received from the United Kingdom whether supplies were likely to be available for export from Ceylon. Grey acetate, as mentioned above, is used for the production of glacial acetic acid, and it is also a source of acetone, a solvent employed in the manufacture of cordite and for other purposes.

Coconut Shell Tar

M. K. Narasimhan (1920) has reported a fairly comprehensive examination of the tar from coconut shells. Wells (1917) had previously given the results of distillation.

A sample of 1,586 grammes examined by the writer gave the following boiling point figures on distillation :—

	Weight in grammes.	Per cwt.	Per cwt. excluding (a) and losses.
B. Pt. up to 120° 268 gm.	187(a)	11·8	—
	61	3·8	4·4
120°–200°	312	19·7	22·5
200°–240°	435	27·4	31·3
240°–260°	95	6·0	6·8
Residue	485	30·6	34·9
Experimental losses	11	0·7	—
	1,586	100·0	99·9

(*a*) was a aqueous layer containing 10·6 per cent. w/v acetic acid. These figures are in general agreement with those of Wells and of Narasimhan. Wells found that 60·5 per cent. distilled below 250°C ; Narasimhan that 69 per cent. distilled below 260°C compared with 69·4 per cent. found by the writer. This percentage of volatile substance is high compared with most wood tars.

The writer confirmed the presence of 5 per cent. of phenol, which was identified as the benzoate m.p. 68°C ; and also found that the guaiacol content (unlike that of beech wood tar) was very low.

Narasimhan (*loc. cit.*) described the residue after distilling off the substances volatile below 260° as a hard brittle pitch. The writer did not find this to be the case. Even after further distillation *in vacuo* at 0·04 mm., by which it was resolved to 20·4 per cent. of the original tar, the residue remained a viscous liquid, which did not harden when exposed to the air for eight months.

A crude shell oil (*pol-katu tel*) is used locally and in other coconut-growing countries as a rough and ready antiseptic. Its preparation using rudimentary apparatus is described by Kidavu and Nambiyar (1927). Compare also Wray (Perak Museum Notes, 1897, 2, p. 35).

Cooke (1936), in his bulletin on the Coconut Industry in the Philippines, states that " it is understood that when coconut shell is steam distilled an oil of medicinal use, having a commercial value in America, is obtained". The writer (1936) was unable to obtain any such oil when finely-ground shells were steam distilled at ordinary pressure, and considers that the reference is possibly to steam distillation of shell tar.

The products from coconut shell tar would, in any case, repay further examination, particularly the creosote fraction.

Table I.—Yields of Primary Products from Dry Distillation of Coconut Shells.
(Percentages by Weight).

	Bull. Imp. Inst. (1916)	Wells. (1917)	Sudborough. (1920)	Georgi. (1929)	C.R.S. (1934)	Danks & Co. (1934)	L.T.C., Ltd. (1934)	Ramachandran. (1938)	
	1.	2.	3.	4.	5.	6.	7.	8.	9.
Charcoal ..	—	32·5	38·3	49·0	30·0	40·6	29·2	37·2	35·1
Pyroligneous acid	—	41·3	35·4	29·9*	38·9		41·3	39·4	41·0
		3·2				37·5			
Tar	—	6·9	6·3	2·9*	4·6		10·7	5·4	7·2
Loss as Gas ..	—	16·2	20·0	18·2	26·5	21·9	16·4 (measured)	18·0	16·7
Acetic acid % in Pyroligneous acid	8·12	—	—	15·8	9·33	—	—	14·0	7·3
Acetic Acid % on shells	—	6·3	6·9	4·66	3·63	—	—	5·5	3·0
Source of shells	(Ceylon)	(Philippine Islands)	(S.India)	(Malaya)	(Ceylon)	(Ceylon)	(Ceylon)	(Bangalore)	(Trivandrum)

*Calculated from values given on basis of Sp. Gr. of pyroligneous acid 1·04 and tar 1·1.

Cf. Also A.I. de Leon and R. O. R. Reyes. "Utilization of some Agricultural Waste Products. I. Destructive Distillation of Coconut Shells, Coconut Husks, Coconut Rachises and Petioles and Rixe Hulls at 400°". *Univ. Philippines Natural and Applied Sci. Bull.*, 1935, **4**, 325–331.

ECONOMIC CONSIDERATIONS

Both Wells (1917) and Sudborough (1920) discuss the economic possibilities in their respective countries, the former giving a comprehensive list of questions which are important factors in plans for a wood distillation industry.

The chief difficulty in any country is the collection at a central factory of sufficient shells for distillation. It seems clear that any plan to undertake shell distillation would only be possible in cases where there is already some centralization of nuts for copra or desiccated coconut manufacture with the exception that it might be possible to modify charcoal manufacture so as to recover crude pyroligneous acid which might be collected for re-distillation at a central place. There are in Ceylon copra manufacturers and desiccated coconut mills capable of handling as many as 15 million nuts a year. This number of shells—some 2,300 tons or about 7 tons per working day—would suffice to keep running a fair-sized installation, using a still of about 30′ × 6′ diam. The shells in such factories are normally used for fuel directly, or burned to charcoal for use in gas engines.

Technically, as has been shown, coconut shells have definite advantages over most ordinary woods for distillation. A favourable feature in Ceylon is the existence of a considerable market for shell charcoal.

It is hoped that further information will accrue from semi-commercial trials projected by the Coconut Research Scheme. In the meantime, this article may be concluded by the writer's opinion that the development of any such industry as wood distillation would not be possible in Ceylon as an isolated project in normal times. It could only be considered in relation to other industrial development.

Interest only attaches to the subject at the present time in view of the possibility of it becoming necessary to meet war-time shortages or inflated prices of commodities essential to existing industries. It may be that no long-continued shortage of acetic acid or long period of high prices will occur, but it is obviously desirable to be prepared to meet such possible contingencies.

SUMMARY

(i.) Destructive distillation of coconut shells may be expected to give per 100 lb. shells, 34 lb. charcoal, 40 lb. pyroligneous acid (of up to 12·5 per cent. acetic acid content), 6 lb. of tar and 20 lb. of gas.

(ii.) 250 to 300 million coconut shells or about 40,000 tons are burned annually in Ceylon to produce about 13,600 tons of charcoal, without attempts to recover by-products. These

would amount to about 16,000 tons of pyroligneous acid (equivalent to 2,000 tons acetic acid) and 2,400 tons of tar. The local rubber industry's requirements of acetic and formic acids do not exceed 500 tons annually.

(iii.) The production of finished chemical products such as glacial acetic acid (99 per cent.) and methyl alcohol cannot be contemplated in Ceylon. The most that could be contemplated is the production of a purified pyroligneous acid for rubber coagulation, and possibly of grey acetate for export. These are believed to be technically possible.

(iv.) The chief difficulties relate to collection and transport of raw material, and the centralization of charcoal production. The chief advantages are the existence of a market for charcoal and, if of sufficiently good quality, for acetic acid, and the fact that shells, by reason of their low moisture content and high acetic acid yield, are particularly suited for distillation.

(v.) The tar contains carbolic acid and creosote. It may be possible to make some use of this locally, but further experimental work is needed.

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LOSSES CAUSED BY MINERAL PHOSPHATES IN MIXTURES WITH SULPHATE OF AMMONIA.

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IN the April issue of this journal there was published an account of the loss of ammonia from a fertilizer mixture in the course of storage during one month. A loss of 18·3 per cent. of the original nitrogen (5·69 per cent.) was recorded, and it was stated that after two months the mixture had become "a damp, sticky mass, resembling puddled clay". The mixture consisted of sulphate of ammonia, Saphos phosphate, and muriate of potash, and the loss was attributed to the interaction of the sulphate of ammonia and the mineral phosphate.

As the writer investigated this matter as far back as 1920, and found negligible losses, it seems of interest to give the results of that investigation, together with two others carried out since.

It is stated by the proprietors of Saphos and Ephos phosphates that these phosphates do not cause loss of ammonia from sulphate of ammonia, and Messrs. Tatlock and Thompson, Analysts, Glasgow, are quoted as having found no loss with Ephos phosphate under temperate climate conditions. As it seemed possible that this did not hold good under Ceylon conditions of high temperature and humidity, a laboratory trial was carried out with Ephos phosphate in August-September, 1920.

Two mixtures were used, No. 1 containing equal parts of Ephos phosphate and sulphate of ammonia, and No. 2 containing 3 parts of Ephos and 2 parts of sulphate of ammonia. From the point of view of this investigation, Ephos and Saphos phosphates are the same. They are different brands of the same mineral phosphate, differing only very slightly in their contents of carbonate of lime and phosphate of lime.

The conditions of this trial were made severe. The ingredients were thoroughly mixed and put through a coffee mill, ensuring finer grinding and more intimate contact of the ingredients than occurs with ordinary mixed fertilizers. The mixtures, weighing about half a pound each, were sampled and placed in open basins, exposing a large surface to the air.

At the end of a week the contents of the basins were again thoroughly mixed, sampled by quartering, and the nitrogen and moisture determined. This was repeated at intervals for approximately 2 months. This mixing and sampling exposed fresh surfaces to the air and increased the liability to loss of ammonia.

The results of the nitrogen determinations are given in Table 1.

		No. 1 Mixture		No. 2 Mixture	
		Nitrogen Per Cent.	Percentage Loss	Nitrogen Per Cent.	Percentage Loss
Mixed	17.8.20	10·20	—	8·28	—
After 8 days	25.8.20	10·06	1·4	8·17	1·3
„ 15 „	1.9.20	10·03	1·7	8·00	3·4
„ 28 „	14.9.20	9·69	5·0	7·83	5·4
„ 63 „	19.10.20	9·55	6·4	7·56	8·7

Table 1.—Loss of ammonia in open basins.

(All nitrogen percentages calculated to original moisture)

The mixtures remained in good condition throughout.

The losses are expressed in the above table as percentages of the total nitrogen at the start. This has been done for comparison with the figures recorded in the publication referred to, but actually the Fertilizer and Feeding Stuffs Regulations in the United Kingdom allow variations which are expressed as percentages of the *whole bulk* (italics theirs). According to these Regulations the lowest permissible limit for No. 1 mixture is 9·90 per cent., while for No. 2 it is 7·98 per cent. Under the conditions of this experiment this drop in nitrogen was evidently reached at some date between the second and fourth week after mixing.

In view of the unnaturally severe conditions of this trial and the fact that negligible losses were found after 15 days exposure, it was concluded that the losses in practice would be considerably less, and that such mixtures could safely be made.

In March this year another laboratory experiment was carried out on the same lines, with the addition of potash to both mixtures. As it had been stated that the danger of loss of ammonia would be avoided by the use of bone meal in place of Saphos phosphate, No. 2 mixture was made up in this way. The mixtures were as follows :—

No. 1.		No. 2.	
Sulphate of Ammonia ..	2	Sulphate of Ammonia ..	2
Saphos Phosphate ..	4	Bone Meal	4
Muriate of Potash ..	4	Muriate of Potash ..	4
	10		10

Two-pound lots of these mixtures were ground to pass through a 1 mm. sieve, sampled by quartering, then placed in large open beakers and left in an airy situation. Sampling was repeated at approximately weekly intervals, the contents of the beakers being turned out, thoroughly mixed, and sampled by quartering. This mixing and sampling accentuated the liability to loss.

Nitrogen was determined in each sample, with the following results. (Table 2).

		No. 1 Mixture (Saphos)		No. 2 Mixture (Bone Meal)	
		Nitrogen Per cent.	Percentage Loss	Nitrogen Per cent.	Percentage Loss
Mixed	8.3.39	4·35	—	5·97	—
After 1 week	13.3.39	4·37	—	5·95	0·3
,, 2 weeks	20.3.39	4·47	—	6·08	—
,, 3 ,,	27.3.39	4·26	2·1	5·77	3·3
,, 4 ,,	3.4.39	4·13	5·1	5·96	0·2
,, 5 ,,	12.4.39	4·21	3·2	5·74	3·8
,, 6 ,,	17.4.39	4·17	4·1	5·60	6·2
,, 7 ,,	25.4.39	4·16	4·4	5·70	4·5
,, 8 ,,	2.5.39	4·27	1·8	5·64	5·5
,, 9 ,,	8.5.39	4·14	4·8	5·71	4·3

Table 2.—Losses of ammonia in open beakers.

(All nitrogen percentages calculated to original moisture.)

These losses are quite small. A variation of 0·5 per cent. of nitrogen is allowed under the United Kingdom Regulations in the case of No. 1 mixture, which means that the nitrogen may vary between 4·85 and 3·85 per cent. The above figures vary between 4·47 and 4·13 per cent. and are well within the limits. In the case of No. 2, a variation of 0·75 per cent. is allowed and the nitrogen figure may therefore be between 6·72 and 5.22 per cent., whereas all the figures lie between much narrower limits. It should be noted that the losses were not diminished by the use of bone meal in place of Saphos phosphate.

These mixtures became somewhat damp in their upper layers after 4 weeks, by which time the moisture had increased from between 2 and 4 per cent. to about 6 per cent. After that the moisture increased more rapidly, and at the end of the 9th week it amounted to 10·90 per cent. in No.1 and 12·80 in No. 2. The mixtures were not unfit for use but were at this stage damp enough to make distribution a little troublesome.

Although neither of these laboratory experiments indicated that Saphos or Ephos phosphate causes serious loss of ammonia, it was considered advisable, in view of the heavy loss reported in the previous note, to make a trial, under working conditions, of the mixture detailed there and also of a similar mixture used on tea. The following were therefore mixed at Hunupitiya Works in the usual way :—

Coconut Mixture.		Tea Mixture.	
Sulphate of Ammonia ..	2	Sulphate of Ammonia ..	190
Saphos Phosphate ..	4	Saphos Phosphate ..	100
Muriate of Potash ..	2	Muriate of Potash ..	30
		Castor Cake ..	30
	8		350

Two-ton lots of each mixture were made up, sampled as they came from the mixer, packed in 1 cwt. bags, and stacked under ordinary conditions of storage. The mixtures were further sampled at weekly intervals, 5 bags being taken at random, put through the mixing machine, and sampled by the usual quartering. This re-mixing and sampling increased the liability to loss compared with a pile of bags left undisturbed. The sampled bags were set aside until the whole had been sampled (8 weeks), they were then all put through the mixer once more and one final sample of the whole was drawn.

The nitrogen was determined in each sample immediately on receipt, with the results shown below. (Table 3).

		Coconut Mixture		Tea Mixture	
		Nitrogen Per cent.	Percentage Loss	Nitrogen Per cent.	Percentage Loss
Mixed	22.5.39	5·07	—	11·75	—
After 1 week	29.5.39	5·18	—	12·27	—
„ 2 weeks	5.6.39	5·21	—	11·48	2·3
„ 3 „	12.6.39	5·18	—	11·95	—
„ 4 „	19.6.39	5·16	—	11·61	1·2
„ 5 „	26.6.39	5·18	—	11·68	0·6
„ 6 „	3.7.39	5·03	0·8	11·71	0·3
„ 7 „	10.7.39	5·15	—	11·68	0·6
„ 8 „	17.7.39	5·20	—	11·27	4·1
„ 9 „	24.7.39	5·11*	—	11·68*	0·6

Table 3.—Losses of ammonia from bags.
(All nitrogen percentages calculated to original moisture).
*Re-mixed samples.

The losses here are quite negligible. The tea mixture was a little difficult to sample owing to the presence of fragments of

castor cake husk, and this accounts for the greater variation in the nitrogen figures which are, however, all well within the limits allowed.

All nitrogen determinations were done in duplicate and agreed well.

The moisture in both mixtures increased with the duration of the experiment, and the figures are given in Table 4. All determinations were done in duplicate.

		Coconut Mixture	Tea Mixture
Mixed	22.5.39	2·60	2·39
After 1 week		2·96	2·60
,, 2 weeks		3·84	3·45
,, 3 ,,		3·91	3·80
,, 4 ,,		3·98	3·67
,, 5 ,,		4·14	3·73
,, 6 ,,		4·31	4·17
,, 7 ,,		4·52	4·40
,, 8 ,,		5·12	5·05
,, 9 ,,		4·72*	4·84*

Table 4.—Moisture absorbed by mixtures in bags.
*Re-mixed samples.

The mixtures felt somewhat damp after about the 4th week, but at no time were they in anything approaching an unusable condition, even when the moisture was at its highest after the 8th week. The test was carried out from the 22nd of May to the 24th of July, a time of rainy weather and humid monsoon conditions, and the mixtures did not become lumpy at any time.

SUMMARY

Three experiments are described showing the losses of ammonia found to occur when mixtures of sulphate of ammonia and mineral phosphates, or bone meal, are stored under varied conditions.

Storage in open vessels in the laboratory caused some loss after about 3 weeks in the first experiment, but very slight loss in the second.

Storage in bags in a shed caused only negligible losses over a period of 2 months.

No confirmation was found of the heavy losses previously reported in this journal, nor of the absorption of so much moisture as to render the mixtures wet and unfit for use.

No advantage appeared from the use of bone meal in place of Saphos phosphate.

A NOTE ON THE LOSS OF AMMONIA FROM FERTILIZER MIXTURES

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IN *The Tropical Agriculturist,* Vol. XCII, No. 4, April, 1939, page 220, one of us (M. L. M. Salgado) reported nitrogen losses of a serious nature on storage of fertilizer mixtures containing saphos mineral phosphate, sulphate of ammonia and muriate of potash. This appeared to be contrary to a reference to the problem made previously in the Annual Report of the Tea Research Institute (Bulletin No. 12), 1934, page 17. As a result of consultation between the Coconut Research Scheme and the Tea Research Institute it was agreed that, in order to resolve the apparent difference in opinion, more detailed investigation of possible controlling factors was necessary.

A detailed joint investigation was therefore planned to examine the following points :—

(1) The behaviour of mineral phosphates derived from different sources, since the chemical composition of the original rock is known to vary with its place of origin.
(2) The effect of the state of division of the sulphate of ammonia.
(3) The effect of the addition of a " conditioner " (10 per cent. of castor cake) to the mixture.
(4) The effect of varying the proportions of the constituents, with special reference to muriate of potash.
(5) The possible influence of climatic conditions particularly temperature and humidity.

We were able to obtain locally by the help of local fertilizer distributors adequate consignments of the following mineral phosphates, Saphos A, Saphos B (A and B representing two different shipments of the same mark), Gafsa, Ephos, and Egyptian. Sulphate of ammonia is marketed in two forms known as " granular " and " rice crystal " and we have compared duplicate mixtures containing these respectively.

The mixtures upon which we have worked were in two series corresponding respectively to the types used on coconut and tea estates. The actual proportions of the various constituents were as follows :—

	Coconut.			Tea.		
	S/Amm.	Phosphate	Mur/Pot.	S/Amm.	Phosphate	Mur/Pot.
Normal	4	4	2	2	4	1
High Potash	4	4	4	2	4	2

All possible combinations of the quantities and types abovementioned, eight in all, have been investigated in 25 lb. lots. In addition, with the courteous assistance of a commercial firm (which we cordially acknowledge), we have been able to examine the losses occurring in eight saphos mixtures (coconut series) under commercial conditions of mixing, bagging, and storage. The Tea Research Institute prepared, stored, and analysed the 40 samples of the tea series, and the Coconut Research Scheme similarly dealt with the 40 samples of the coconut series. The latter station dealt with the sampling of the commercial series, whilst as an additional check the Tea Research Institute duplicated the eight Saphos A samples of the coconut series. All samples were examined for moisture and nitrogen content initially, and after intervals of 9 and 30 days respectively. The commercial samples were in addition examined after 60 and 90 days, and the tea mixtures after 60 days. Methods of preparation, sampling and analysis were jointly standardized.

The preparation for publication of the considerable amount of data accumulated will of necessity take some time. We feel, however, that in view of the inquiries that have been received by the two stations since the original note was published (*loc. cit.*), an interim report is desirable, particularly since similar work in the same field by P. A. Keiller appears in this number of *The Tropical Agriculturist.* By the courtesy of Mr. Keiller we have been able to see a copy of his paper in advance of publication.

It may be said at once that we have found in no case losses comparable with those previously reported; and in fact such losses as we have observed are very similar in magnitude to those recorded by Mr Keiller. As typical of the results obtained, the following example shows the average loss found on the eight saphos A laboratory samples of the coconut series :—

Nitrogen Contents of Stored Manure Mixtures.

	On mixing.	After 9 days	After 30 days	Total gain or loss.
Nitrogen content (per cent. on dry)	7·47	7·50	7·30	— 0·17
Moisture content per cent.	2·24	4·26	7·92	+ 5 68

Our observation that the commercial samples picked up much less moisture (per cent.) than the 25 lb. samples (an increase of 2·04 per cent. as against one of 5·68 per cent.) makes it highly probable that the greater loss of nitrogen from the smaller samples of 1 lb. weight used in the original investigation (*loc. cit.*) was due to the more rapid uptake of moisture from the very earliest stages.

It now seems clear that the previous findings reported in this journal were based on preliminary results obtained from samples which were too small for practical purposes. This may also apply to the Malayan work referred to previously.

The detailed results of our findings will be published in due course but we can state at this point that, in the light of this more comprehensive investigation, there is no reason to fear appreciable loss of nitrogen from manure mixtures containing mineral phosphate, sulphate of ammonia, and muriate of potash, stored under reasonable conditions.

A CONVENIENT METHOD OF DETERMINING THE INCUBATION PERIOD OF A PLANT PATHOGEN IN THE FIELD

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THE need for direct field studies of plant pathogens is becoming increasingly evident. Estimates made in the laboratory or in the greenhouse of the incubation period of a pathogen have often little relevance to the complex conditions obtaining in the field. Besides, it is often a difficult matter to satisfy Koch's postulates; inoculation, in many instances, may not "take". In the following note is given an account of a simple technique of estimating the incubation period of a pathogen in the field. The method was developed in connexion with the frog-eye disease of tobacco, but should find application to many of the diseases that are amenable to control by the use of protective fungicides. The continuous, natural deposition of appreciable quantities of inoculum on the host surface is an absolute *sine qua non* for the successful working of the method. The technique is best illustrated by citing the instance of a specific disease.

When a tobacco crop is approaching maturity, the density of frog-eye conidia within the crop attains, at least under Ceylon conditions, a very high value, and numerous leaves occur which, besides exhibiting macroscopically visible lesions, carry several latent infections. If a leaf of this type is left intact, the latent infections show up on the expiry of the complete incubation period, and the continuous deposition of conidia on the leaf surface, in the meanwhile, results in further infections. A record of the numbers of lesions on such a leaf plotted against time, exhibits an uninterrupted and, as a rule, continuously accelerated rise (Fig. 1B). If, on the other hand, a leaf of the type discussed above is sprayed with a protective fungicide, the appearance of the symptom picture of latent infections will not be affected, but conidia falling on the leaf

subsequent to spraying will either be killed, or at least prevented from establishing infection. The symptom picture curve for a sprayed leaf will accordingly continue to ascend for a period not exceeding the incubation period of the fungus, and then suddenly flatten out and run parallel to the time axis (Fig. 1A). The interval between the date of spraying and the date of this change of direction of the symptom picture curve, provides an estimate of the incubation period. A protective fungicidal cover is rarely completely effective, partly as a result of poor adhesion and imperfect toxicity of the fungicide, and partly due to continued extension of the host surface ; a few infections often continue to establish themselves even after spraying. The latter part of the symptom picture curve is hence, as a rule, not perfectly horizontal, and the change of direction may not be well-marked. In such instances, the symptom picture curves of sprayed and untreated leaves may be suitably juxtaposed, and the interval between the spraying date and the date of divergence of the two curves will provide an estimate of the incubation period.

Actual records of lesion numbers made at the Experiment Station, Ganewatta, during the *maha* season 1938–39, have been plotted in Fig. 1. Selected leaves were sprayed on January 17, 1939, and lesion counts of sprayed and untreated leaves were made during the period January 19–28. The incubation period of a frog-eye lesion as determined by these records is 5–8 days.

The selection of leaves with the appropriate degree of infection and of a suitable spraying date, is of importance. The leaves should at the time of spraying have attained their maximum extension and should exhibit a few lesions. The spray should be applied when the symptom picture curves are rising steeply. It should be noted that, if the infection curve of a disease is inherently sigmoid, the curves for intact leaves too will, if continued for a sufficient period, exhibit a natural flattening out.

Strictly comparable symptom picture curves for sprayed and untreated surfaces can be obtained by applying the protective fungicide to one half of a leaf, and leaving the other half exposed to infection.

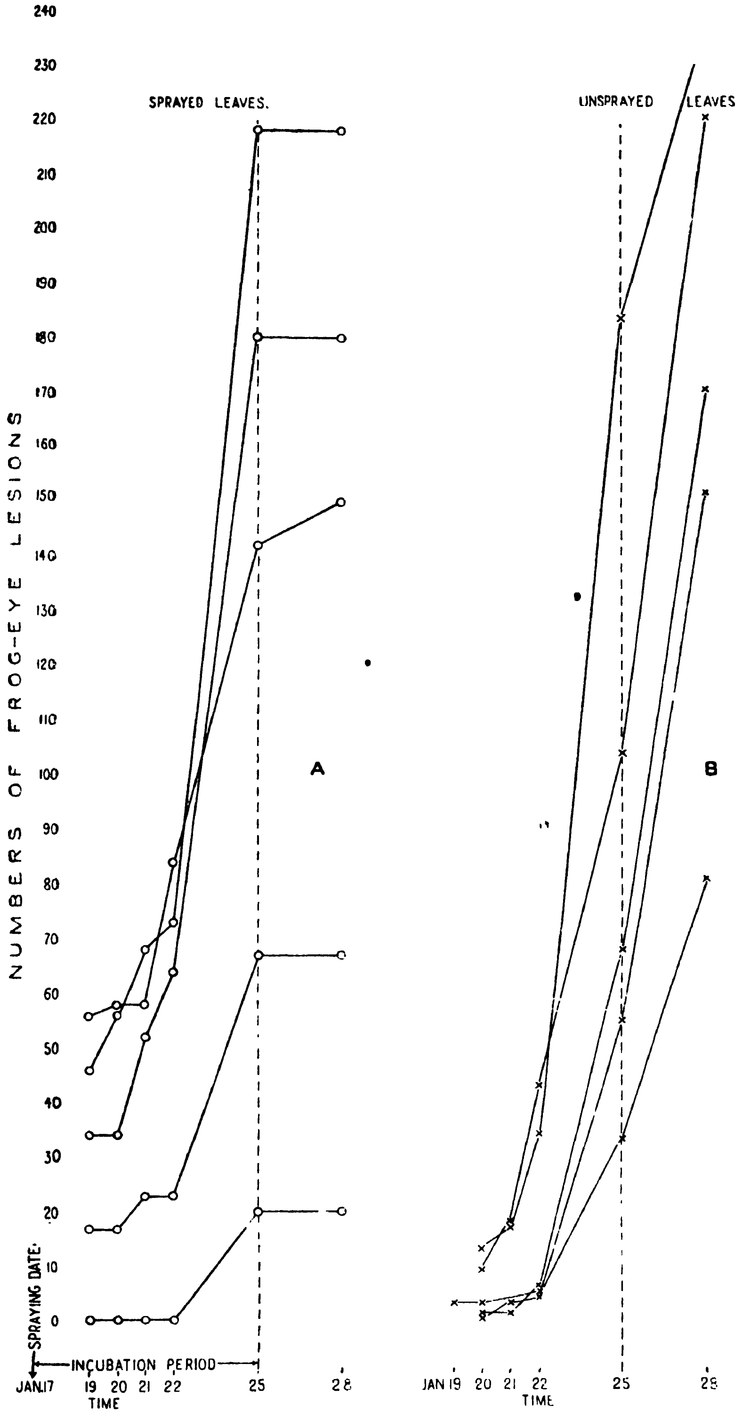

FIG. 1.—THE COURSE OF FROG-EYE INFECTION IN SPRAYED AND UNSPRAYED LEAVES OF TOBACCO.

CATASETUM MACROCARPUM RICH.

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C*ATASETUM macrocarpum* Rich. belongs to a genus of both epiphytic and terrestrial orchids of which there are about 40 species all confined to the tropical parts of America.

This orchid with its green plaited membranous leaves and thick and succulent pseudo-bulbs resembles a *Calanthe* when not in bloom.

The flowers are remarkable for their peculiar distinctiveness and beauty of structure. The flowers are borne on an arching raceme from a leafscar at the base of a pseudo-bulb. The flowers before opening bear a striking resemblance to a small bunch of green fruits. The sepals and petals are of a firm leathery texture, converging to form a hood. The fleshy lip is deep orange and is pouch-like. The column is long and erect terminating in a point-like horn with a pair of long, deflected and slender outgrowths like tendrils in the middle.

Though the flower does not open out fully, it is as large as three inches in diameter. The convex sides of the sepals and petals are green and grade into a pinkish-yellow of fringe at the edge, while the concave sides are thickly mottled and striped with purplish brown.

Culture.—Catasetum is not at all a difficult subject for cultivation, the main requirements being plenty of light and moisture during growth with a view to developing the pseudo-bulbs to maturity.

The plant thrives either in wooden baskets or perforated earthen pots suspended from the roof. Though the plant was originally found growing on the ground in decaying vegetable matter, it has since been treated as an epiphyte and cultivated in a mixed compost of half-decayed leaves, chopped moss, bits of charcoal, bone and well-burnt brick. The bottom of the basket should be packed with a layer of moss or half-decayed leaves mixed with rough sand; and after setting the plant, the rest of the compost should be evenly placed round the plant, and the basket well shaken to ensure firm setting. The plant is then given a good soaking in water, and is placed in the shade

with ample light. After the first watering the plant requires little moisture until the new growths appear. Care in watering is necessary till the plant has become established and when in active growth water should be copiously supplied, as fast as the compost dries.

The plant needs the maximum light under shelter during the season of growth. It shows a partiality for atmospheric moisture but overhead syringing will damp off the young shoots at the early stage. The safest method is to water the plant at the roots and to wet the environment. As soon as the leaves turn yellow after flowering, the water supply should be reduced, and when these have dropped, discontinued altogether for a few days.

If the pseudo-bulbs are plump, only an occasional watering will be required until the plant again shows signs of activity.

Catasetum macrocarpum RICH

DEPARTMENTAL NOTE

GUMS AND RESINS

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THERE are in Ceylon numbers of trees which yield gums or resins, and while it is unlikely that an export trade in these products will ever be developed, nevertheless it is possible that some of them may be of use as local substitutes for products that are now imported. The following brief notes refer to trees that are all wild and of common occurrence, and apparently of sufficient promise to be worth investigation. It is not suggested that they should be planted, at least at first ; the utilization of wild trees will suffice to indicate the possibilities of any of them as sources of marketable gums or resins.

1. *Limonia acidissima* Linn. (= *Feronia elephantum* Corr.)

Wood apple

S. Diwul

T. Vila, Vilatti, Mayaladikkuruntu.

A small tree which occurs very commonly throughout the dry regions. The trunk yields a gum which strongly resembles gum arabic, for which it may be used as a substitute. It should be suitable for local use as a mucilage. It is used medicinally in India, in place of gum arabic.

2. *Lannea grandis* Engl. (= *Odina Wodier* Roxb.)

S. Hik

T. Odi

A small tree which occurs commonly in both dry and wet low-country, but especially in the former. A gum runs from the stem which is used in India as size for whitewash and in calico printing.

3. *Canarium zeylanicum* Bl.

S. Dik-kekuna, Kekuna

T. Pakkilipal

Common in the low-country. Yields an abundance of a clean fragran, gum-resin which is used for fumigation and is also burnt for light in houses mixed with sand. It resembles elemi, which is used medicinally for making ointments.

4. *Dipterocarpus zeylanicus* Thw.

S. Hora

A large tree occurring commonly in the moist low-country. Yields a semi-liquid gum-resin that may be of use for varnish and lacquer.

5. *Doona zeylanica* Thw.

S. Dun

T. Koongili maram

A large tree, common in moist regions between 1,000-4,000 feet. An excellent colourless dammar-like resin exudes from the trunk, and could be used as a substitute for dammar in varnishes.

6. *Garcinia Cambogia* Desrouss.

S. Goraka

T. Koraikkapuli

G. Morella

S. Kanagoraka, Goraka, Kokatiya.

T. Makki

Both species occur commonly up to 1,500 feet in the moist region. Both yield a gum-resin, that of *G. Cambogia* being useful as a varnish and that of *G. Morella* being the true Gamboge of commerce, used as a pigment.

7. *Semecarpus Gardneri* Thw.

S. Badulla

A moderate sized tree occurring commonly in the moist low-country. The bark yields an almost-black resin which may form the basis of black varnish.

8. *Vateria copallifera Retz.* (= *V. acuminata* Hayne.)

S. Hal

A large tree occurring commonly in wet districts up to 2,500 feet, especially near streams. The stem exudes an abundance of a clear yellowish resin equal to the best dammar.

9. *Vatica chinensis* Linn. (= *V. Roxburghiana* Bl.)

S. Mendora

A moderate-sized tree rather common in the moist low-country, especially near streams. An abundance of a yellow transparent resin exudes from the stem, which should have a use similar to that from Vateria.

SEASONAL PLANTING NOTES

CALENDAR OF WORK FOR DECEMBER

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TAKING the country as a whole, December is a very favourable month for nearly all garden operations. It is a time when the more tender seedlings ("tender" here refers to such plants as are very delicate in the seedling stage but which usually strengthen rapidly afterwards) can be put out and the earlier plantings consolidated. Before planting, some care should be taken in soil preparations to see that the manure used is not too fresh. Only well-decomposed manure should be used and this is best done if broken up or even sifted, and incorporated in the surface layer of the bed or border. Sifted leafmould too, if available, is a very helpful medium to encourage weakly-constituted seedlings to go ahead.

Up-country, conditions are generally moist and cool, with strong winds prevailing in certain areas. Support should, therefore, be given to such plants as are of rapid growth and to all young trees in exposed positions. Certain shrubs, such as *Streptosolen*, *Heliotropium*, suffer from the effects of frost, and from now onward, to the end of January, preparations should be made to afford cadjan or hessian cover during nights when a frost is anticipated. Damping-off of plants, still in the seedling stage, must still be guarded against, dustings with flowers of sulphur being the usual remedy.

Requests are frequently received for advice on the formation of rock gardens. This form of garden is more adapted to temperate and sub-temperate than to tropical regions.

Owing to our extreme conditions and paucity of tropical varieties of suitable plants, the same degree of perfection cannot be attained here as in temperate climates, nor can the features of a true rock garden be expected, but, nevertheless, quite an interesting garden design, on the lines of the rockery proper, can, with care and judicious selection, be secured. The first requirements are a fairly open site, preferably one with shade trees on the western side, a suitable type of rock or stone,

a reliable water supply and good drainage. The rocks should be rough, bold, weather-worn and not too small. They should be placed in a manner similar to that in which they would lie in their natural state, being partly buried in the ground and not merely laid on the surface. They should be laid in irregular outline but following one general direction so as to resemble the natural strata.

Fair-sized pockets, sufficiently large to make a good show of any one type of plant, should be arranged for, the pockets being filled with good soil such as potting mixture, including well-decomposed leafmould and sand, the coarser material with bricks, &c., for drainage being placed in the bottom of the pocket. Soil of finer texture should be applied on the surface.

Much now depends on the selection of plants made, and for a rockery of the above description plants of dwarf and evergreen habit should be used together with succulents and bulbs. Useful varieties of dwarf habit for the foreground should include torenia, the small creeping variety of *coleus* (*Coleus Rehneltianus*) *Ficus pummila*, santolina, dwarf caladium (*Caladiums Humboldtii*) dianthus, achemenes, gerbera, petunia, portulacca, *Phlox Drummondii*, sedum, verbena, ophiopogon, the creeping balsam (*Impatiens repens*), alternanthera and candytuft. For filling the pockets, in the main, the following will be very suitable and attractive :—plumbago, turnera, angelonia, coreopsis, exacum, gynandropsis, variegated pineapple, *Salvia farinacea*, *Scutellaria* (scarlet and blue), vinca, asystasia, kalanchoe, crossandra (all species) the small scarlet euphorbia (*E. Bojeri*) *Russellia juncea* and *Sophora violacea* among many others.

Another form of rockery which is becoming more popular in small gardens is the rockery-cum-fernery. This type of rockery is suited to those plants which thrive under shady conditions. Moisture and good drainage are essential in this type of garden, and also good shade for the greater part of the day. The idea is a reproduction, more or less, of the characters of a plant-covered bank so often seen along or near the roadside in jungle or forest areas. A few rocks inserted in a bank here and there as a basis, and around which, in prepared areas, are planted such shade-loving plants as can be accumulated, is the idea. The soil in such cases needs to be light and to consist chiefly of leafmould, sand and any mossy material available, with a dressing of good black garden soil. Chopped-up, dried roots of *Gleichenia linearis*, the Ceylon " Kekila " obtained from partially-drained boggy areas, are a useful acquisition for the fern representatives of such a rockery. In general, the condition under which such plants grow and flourish in their natural conditions should be reproduced as nearly as possible.

To this end, the following selection of plants should be suited to (and thrive in) low-country and mid-country elevations :—begonia (Rex and others) isoloma, balsam, selaginella of several varieties, caladium varieties, the hardier varieties of anthurium and peperomia, *Achmea fulgens*, several species and varieties of dieffenbachia, calathea, costus, tradescantia (for edges), *Strobilanthes dyerianus*, *Gynura bicolor*, sansevieria, episcia, maranta, ophiopogon (for edges), philodendron, eucharis lilies, alpinia, fittonia (of creeping habit with handsome net-veined leaves, white, reddish and pink) and saintpaulia, the latter only for elevations above 1,500 feet.

Fern selections to accompany the above should include a single individual here and there of the only Ceylon low-country tree ferns *Alsophila glabra* and *Hemitelia Walkerae* with angiopteris and varieties of the maidenhair group, asplenium, blechnum, lomaria, nephrodium, polypodium and varieties of *Pteris*. Gymnogramme, commonly known as the "gold" and "silver" fern, does best in sunny positions and is almost the only fern so to adapt itself. Though ferns are not difficult to cultivate, they invariably feel the shock of transplanting and some time must elapse before they are able to establish themselves from such transplantings. • Plenty of water to ensure a moist environment is the best means of reducing this period of recovery.

At this season of the year soil-nesting termites are extremely active. A very sound remedy to apply to all termite mounds observed to be in the process of formation is to close all outlets except one. Through this remaining opening, petrol should be poured by means of a funnel pipe or piece of small-sized bamboo section using about a quarter of a cigarette-tin-full of petrol to a small mound. This remaining opening should immediately be sealed up to prevent the escape of petrol vapour. The petrol vapour works through the termite channels and results in the destruction of the whole colony. At Peradeniya the gardens in past years suffered severely from such attacks, but this simple remedy has here proved entirely effective.

In this month vegetable cultivation calls for some attention. December is an ideal month for raising quick-maturing vegetables.

The best site for vegetable gardens is a flat open one, but any hilly site can be utilized if terraced. Shade from the hot afternoon sun is most advisable and in the selection of any new site this should be borne in mind. The ground should be well prepared by double digging, *i.e.*, to a depth of approximately 16 in. to 18 in., and well-decomposed manure or any form of humus incorporated in the surface layer of 6 in. to 8 in. of soil.

The double digging is for aeration purposes and it is not necessary that the manure should be buried too deeply.

Having brought the surface to a fine tilth, sowing can proceed, or if the seed has been already sown in boxes, transplanting can be undertaken. Separate articles are published by the Department of Agriculture, Peradeniya, giving details of planting distances, time of maturing and other particulars of a variety of crops but for purposes of this calendar the following selection might be grown for quick returns with advantage :—beans (French, cluster, Egyptian, lima, &c.), brinjals, carrots, chillies, cucumber, kohl-rabi (knol-khol), bandakka, maize, pumpkin, radish, shallots, spinach, sweet potato and tomato.

Of the above, bandakka and radish give the quickest returns. Village gardeners in the dry zone can make much of such varieties of food crops as cowpea, snake gourd, bitter gourd, luffa and melons in addition to some of those previously mentioned. Seed of most of the above is procurable from the local stores, market stalls and Colombo nurserymen whilst the Agricultural Instructors in the various ranges can also afford facilities for procuring such seed.

SELECTED ARTICLES

WATER CONDITIONS OF THE SOIL AND IRRIGATION*

THE water condition of the soil is a decisive factor in plant life : the moisture extracted by the plant from the soil forms the main component part of the body of the plant amounting to 90 per cent. of its total weight. Water and its component elements alike form essential parts of the organic compounds of the plant ; mineral nutrition can take place only with the active assistance of water, which also helps the process of synthesis, hydrolysis and general metabolism in the plant. Practical investigation of the problem of water supply to citrus trees in Arizona established the fact " that intelligent irrigation " was " of much greater importance than fertilizer practice " and that was " being found to be true in California."

INTER-RELATIONSHIP OF SOIL AND WATER

The content of moisture in the soil, known as " soil moisture ", is of great importance in the production of plants. A decrease of the amount of moisture in the soil beyond a certain limit arrests the growth of plants ; this characteristic explains the sterility of dry regions and arid lands. Excess moisture, too, hinders and sometimes even arrests growth. This is why artificial irrigation does not mean merely the supply of water to the soil, but should strive to reach a definite optimal content. The degree to which water is bound to the soil or is free to move there, is determined by the mutual attraction of soil and water particles, which can only be explained by the application of physical and chemical laws to these phenomena.

All phenomena of water retention in the soil, its movement inside the soil, and its flow downwards towards the earth, can be explained by the presence of two kinds of forces acting in the environment formed by soil and water : (*a*) the force of mutual attraction affecting particles of soil and water, (*b*) the force of gravity exercised by the earth, which affects the movement of water in a vertical direction from the soil to the subsoil and deeper.

Three types of moisture are distinguished in this connection : hygroscopic, capillary and gravitational moisture, though no definite transitional limits can be fixed between them (1 : 2). Hygroscopic moisture adheres very strongly to the particles of soil ; the pressure necessary to separate it from the particles of soil is fixed at 1,000 atmospheres. Hygroscopic moisture is situated on the surface of hard particles and is not capable to move about in liquid form. At a further increase of the moisture content, water does not come into direct contact with the hard substance of the soil, but with the layer

* By Professor F. Menchikowsky, in *Hadar*, May 1939, Vol. XII, No. 5.

of hygroscopic moisture previously introduced into the soil. The mutual attraction of this additional water and the soil is weaker than that of the preceding supply, so that the new moisture can now move inside the soil in all directions, without yet being subject to the force of gravity exercised by the earth. This moisture, too, is retained by the soil, but a pressure of 5–15 atmospheres suffices to separate it from the soil. Since it is generally assumed that this moisture occupies the capillary spaces in the soil, and maintains itself there partly owing to capillary attraction, it is known as " capillary moisture ". Any further increase of moisture in the soil leads to the accumulation of water retained in the soil with difficulty ; this water, therefore, drains down as a result of the terrestrial force of gravity. This water is known as gravitational moisture.

RISE OF WATER IN THE SOIL AND CAPILLARY MOISTURE

If soil comes into contact with a surface of sub-soil water at a certain depth, so that all soil capillaries are filled with water, we enter the domain of physical capillary phenomena. Water rises on its own in the capillary spaces of the soil and reaches a certain level, at which the weight of the rising column of water is counter-balanced by the action of intermolecular soil forces. Physical laws teach us that such capillary rise depends on the diameter of the capillaries in a reversed proportion, the narrower the opening the higher the rise. At the same time, observations prove that in these circumstances capillary moisture attains a maximal rise in loamy soil, a lower rise in sandy-loam, and a minimal rise in sandy soil.

Another feature of the capillary rise in these conditions is that the percentage of capillary moisture decreases with increased height. This circumstance, too, is in strict conformance with the laws of capillarity, and is an extremely important factor in the artificial and natural moistening of the soil.

However, several scholars draw a distinction between the upper and lower zones of capillary moisture (Keen, Versluys, Vageler).

The upper zone of capillary moisture is not completely full with water and the capillary attraction gives, therefore, place to the forces of physico-chemical adhesion.

This is the zone of " open " capillary moisture, the air spaces of which amount to about 24 per cent. of the total soil porosity, which is most favourable to plant life. The following are the types of moisture from soil surface downwards :

Soil surface

---

hygroscopic moisture

↓

" open " capillary moisture

↓

" closed " capillary moisture

sub-soil water.

TYPES OF MOISTURE IN THE SOIL AND WATER REQUIREMENT OF THE PLANT.

As is well known, plants require an uninterrupted supply of water, without which they cannot exist. This supply is assured by the root system, which develops a certain sucking power, that grows as we proceed from the periphery to the centre of the root, and fluctuates between 1 and 10 atmospheres.

Comparing these data with the forces that retain the three above mentioned types of moisture in the soil, we find that the one corresponding to the suction power of the root is the capillary moisture (5–15 atmospheres). As the stock of capillary moisture in the soil decreases, the plant experiences growing difficulties in the extraction of moisture from the soil; the plant begins to wither, and as soon as the amount of moisture falls short of a certain limit, it perishes. At this critical moment the soil still has a certain stock of moisture, but the latter is inaccessible to the plant, since physiologically it forms the "dead moisture" store. This unavailable stock of moisture in the soil corresponds more or less to what we call hygroscopic moisture.

Gravitational moisture fills the non-capillary hollows of the soil, which spaces are as a rule filled with the air necessary for the breathing of roots. The presence of this type of moisture has a bad effect on the physiological conditions indispensable for the life of the roots; and consequently, gravitational moisture is considered detrimental as causing diseases, and sometimes even the death of plants. The following sketch illustrates the relation of the various types of moisture to the water requirements of the plants.

Moisture.

	hygroscopic	capillary	gravitational	
	↓	↓	↓	
Dry soil	unavailable	available	injurious	Soil saturated with water
	↓	↓	↓	
	too dry	optimal	too wet	

for plant growth

CONSTANTS OF SOIL MOISTURE AND COEFFICIENTS OF PLANT GROWTH

The above shows that a plant has definite requirements as far as moisture content in the soil is concerned. Under certain circumstances, which are optimal for plants, the latter attain maximum growth, while a different content of moisture in the soil brings about the death of plants. Two coefficients of soil moisture, which are biologically important, have been established in this connection. One of these is known as "permanent wilting point"; it designates a physiologically minimal content of moisture in the soil; as soon as this is reached, the plant withers and dies. The second coefficient denotes that moisture content of the soil, which brings about the optimal conditions of growth and development of the plant; it is known as the "optimal moisture content". Successful practising of artificial irrigation requires the determination of these two coefficients for every type of soil. These coefficients of growth can be found with the help of the constants of soil moisture, which

determine the capacity of the soil to retain moisture. Of the several known constants we shall discuss only two, acquaintance with which is indispensable for an elementary comprehension of conditions of soil. One of these is the "hygroscopic content". The determination of this constant aims to find out the amount of water in the soil, at which the latter becomes covered with a thin film of hygroscopic moisture. The second constant, which is very important in practice, is known as "capillary capacity"; it presents the amount of water required to fill a given volume of soil with capillary moisture.

CONSTANTS OF SOIL MOISTURE AND MOISTURE REQUIRED BY CULTIVATED SOIL

As a result of the absorption of moisture by cultivated plants the amount of moisture in the soil decreases till the agriculturer must have recourse to irrigation. This critical moment, when the agriculturer must interfere, can be determined by noticing colour (dark-green colour in lucern) or the first symptoms of wilting (drooping leaves). However, a more rational method is to test the amount of moisture in the soil, the content of which should never be allowed to fall below the permanent wilting point. This point can be determined within given limits in every type of soil by means of the constants of soil moisture. It is impossible to discuss here at great length the complicated systems of determining the wilting point evolved by U. S. A. scholars (L. Brigg, H. Shantz, F. Veihmeyer, O. Israelsen and others). We shall only mention Bogdanoff's finding, that the amount of water unavailable to the plant as a "dead moisture" store is approximately double the quantity of hygroscopic moisture in air-dry soil.

This limit of the content of moisture in the soil, which forms a natural boundary beyond which no plant life is possible, closely depends on the mechanical composition of soils.

Coarse sandy soils continue to deliver moisture even when its content is reduced to 3 per cent. or less. In loamy soils this limit is reached at 20 per cent. In the loamy soils of our littoral zone the "dead moisture" store fluctuates, according to observations made by the author, between 20·2 per cent. and 21·0 per cent. This fluctuation of the amount of moisture unavailable to plants is of great importance to nature, for coarse soils with a small water capacity enable plants growing in them to utilize almost their whole stock of water.

THE EFFECT OF MINERAL ELEMENTS ON THE AVAILABILITY OF SOIL MOISTURE

Artificial irrigation as such forms an interference with the normal course of things in the soil under natural circumstances; it may, therefore, cause a change for better or for worse, as far as the plant is concerned. In irrigating the farmer introduces annually into the soil a considerable amount of mineral compounds in the shape of salts of Na, K, Ca, NH_4, &c. One part of these salts remain in solution thereby increasing the concentration of the soil solution, while another part is absorbed by the soil, as a result of which the physico-chemical properties of the soil undergo a change. It has already been mentioned that soil has a definite force of binding moisture; as the amount of moisture

in the soil increases, this binding force decreases. The strength of these forces of adherence in the soil plays a very important role in the life of plants, for in the case of soils with a high capacity for binding moisture, sucking roots often experience difficulties and sometimes fail altogether to extract moisture from the soil. Soluble salts are subject to solvatisation, *i.e.* to become covered with an outer "rind" of water particles, thereby decreasing the available amount of moisture in the soil, which the plant is capable of assimilating. These phenomena have formed the subject of investigations made by several scholars. Their observations prove that one and the same amount of water in the soil may supply the plant with systematically decreasing quantities of available moisture, depending on the fact whether the soil had not been fertilized at all, normally fertilized or enriched by a high content of K-salts. In saline soils, or in such as have a tendency to accumulate soluble salts—as a result of climatic, topographical or soil conditions, mineral fertilization may become a factor that hinders growth or even arrests it altogether if intensive mineral fertilization is practised in the case of limited quantities of available moisture. In the agricultural practice of Palestine, where growth depends on rain precipitation, one can observe quite often that the first to suffer at a period of drought are those plots that have been abundantly supplied with chemical fertilizers.

The study of soil from the point of view of its saturation with various mineral bases, proved that physico-chemical properties, too, are conditioned to a large extent by the nature of the absorbed elements. The same is true also with regard to the degree, to which such soil binds moisture. The soil becomes covered with a "rind" of water particles, the formation of which depends on the absorbed elements, their quantity and form.

Consequently, mineral fertilization affects the balance of free moisture, available for assimilation by the plant, not only as a result of the change that takes place in the nutritive solution of the soil, but also as a result of the change that takes place in the soil itself, a change effected by the process of mineral fertilization.

ACCUMULATION OF WATER IN THE SOIL

It has already been stated above that the initial moment of irrigation is connected with the critical stage, at which the plant begins to experience difficulties in its biological activities as a result of the decreasing content of moisture in the soil. The supply of water to the soil at the time of irrigation aims to raise the content of water in the soil to a limit which would represent optimal conditions as far as the plants in question are concerned. Within the scheme of various types of moisture in the soil it means the formation of "capillary moisture". Maximum capillary moisture is known as "field capillary capacity". In practice capillary moisture can be determined in the field by ascertaining—after all gravitational moisture had run off—the percentage of moisture in a given plot protected from evaporation, in which underground water is situated at a considerable depth. (Under laboratory conditions this amount is approximately equal to the "moisture eqivalent" *i.e.* the quantity of water, which Briggs and McLane found in a soil-sample after subjecting it to centrifuging for half an hour in a centrifugal machine, the centrifugal force of which is 1,000 times stronger than the force of gravity.

By filling the soil with water up to the above mentioned limit we create in the soil a store of water, which ensures the growth of the plant under optimal conditions during a certain period of time. In this condition some of the soil pores are filled with air. Strict care must be taken not to exceed this limit, since with the introduction of gravitational moisture, which lies beyond the limits of " capillary moisture " conditions become dangerous to the growth of plants.

On measuring the amount of moisture in the soil up to a certain depth (2ms), when maximum capillary capacity is achieved, and deducting the percentage of moisture in the soil at the initial moment of wilting, we find that store of water, which the soil may and must contain under normal conditions of irrigation.

Of course, the duration of the period, in which this store is exhausted by the soil, depends on the type of plants, their age, climatic conditions and the rate of evaporation on the surface of the soil (11).

DELIVERY OF MOISTURE FROM THE SOIL TO THE PLANTS

The characteristics of the delivery of available capillary moisture to the plant are not less important than the total quantity of delivered moisture and the upper limit of this delivery. The fundamental factor that determines the character of the water economy in the soil, is probably that absorptive quality of the particles of the soil, which is determined by their chemical properties, and is known as sorption. This property to form more or less thick " rinds " of water particles round particles of soil is responsible not only for the total amount of all types of moisture in the soil and their distribution, but also for the process of water delivery to plants. The study of the latter shows that it is not uniform. At first the delivery of water is rapid, then it slows down, and finally, as the hygroscopic coefficient draws nearer, the delivery almost stops. The following scheme illustrates this process in various types of soil :

	loam	sandy-loam	sand
hygroscopic and capillary moisture	high	middle	low
water delivery	slow	middle	quick

SURFACE EVAPORATION AND CONSERVATION OF SOIL MOISTURE

Surface evaporation was considered to be one of the factors effecting a decrease of the total store of moisture in the soil. This opinion rested on the assumption that capillary moisture filled all capillary spaces in the soil, and as soon as the upper layer of the soil was dried, the moisture stored in deeper strata ascended towards the surface. Had this assumption of the properties of capillary moisture been correct, the latter should have filled all hollows in the soil, without leaving any space at all, or only very little space, for air. Actually, a somewhat similar state of affairs is to be found only where the sub-soil water is close to the surface, when a type of " closed " capillary moisture is formed, as we have had occasion to notice above. Under normal

conditions capillary ways are interrupted by air bubbles and the movement of moisture meets with difficulties. Observations made by F. J. Veihmeyer in California showed that loss of moisture by evaporation affected only 15 cm. of the surface layer of soil. Deeper strata do not lose any moisture as a consequence of this phenomenon. This assumption has been confirmed both in soil-tests in the laboratory as well as observations in the field. At the same time these observations showed that cultivation of the soil does not affect the conservation of moisture, contrary to former suppositions that mechanical cultivation destroys capillary connections in the soil.

The loss of moisture in uncultivated soil should be ascribed exclusively to the evaporating properties of weeds that cover the surface of such soils Cultivation helps to decrease evaporation only in that sense that it destroys the cover of field-weeds.

THE CONTROL OF WATER RELATION IN LOCAL SOILS AND IRRIGATION

Local climatic conditions render artificial irrigation indispensable, if a certain degree of soil-fertility is to be maintained. Consequently, it is necessary to take into consideration all factors affecting moisture in the various types of local soils. The usual system of irrigation does not always satisfy the requirements of plants, for it sometimes allows moisture to fall below the above mentioned critical limit, or else it enriches the soil with water far beyond the limits of capillary moisture. Citrus trees belong to that category of plants which are extremely sensitive to both deficiency and excess of moisture in the soil; a large number of diseases of citrus trees and seedlings is to be ascribed to either of these deviations from the standard. On determining the stock of optimally absorbable water, which corresponds to capillary moisture, and establishing the water requirement of the trees in the plantation, we can find out and fix the suitable interval of time between two consequent waterings. In the campaign against faulty irrigation one more factor plays a decisive role, namely the exact knowledge of the level of uppermost sub-soil waters, which may create a non-uniform distribution of moisture in the soil, more especially in deeper strata that lie near the level of these underground waters, where "open" capillary moisture turns into "closed" capillary moisture poor in air. Such unfavourable conditions prevail under local conditions in saturated plots lying in the vicinity of "wadis."

The problem of water delivery from the soil to the roots of plants has not been sufficiently considered as yet. It had been assumed that the flow of moisture to the roots was uniform, while in practice immediately after a watering the plant requires less efforts to obtain the requisite moisture than it does before a new watering. Another factor that is to be taken into consideration in this respect is the nature of chemical fertilization, for it affects the degree to which soil binds moisture or renders it available.

In the light of our present knowledge of soil moisture and its relation to plants, irrigation of plantations can be successfully achieved only if it is guided by a control of the interrelation of moisture and soil.

THE CULTURE OF THE PAPAW*

THE papaya (*Carica papaya*, L.), or papaw as it is popularly called in South Africa, is indigenous to Tropical America, but its exact origin has not been determined. Related species grow wild in that country, and the papaw is believed to have originated from a cross between two of them. It is an important crop and is at present grown in practically all the sub-tropical and tropical countries of the world. As a health-food the papaw has few equals, and it should receive wider recognition in countries outside the tropics.

DESCRIPTION

The papaw is a large herbaceous plant with a hollow and fibrous trunk. The leaves are usually seven-lobed, two or more feet across, and are borne on long leafstalks, so that the general appearance of the tree is somewhat palm-like.

The groves in South Africa are mostly composed of dioecious varieties (male and female flowers borne on separate plants) with a small percentage of monoecious types (male and female flowers borne on the same plant intermixed). With the exception of fruit and flower characteristics, these sex forms are identical in general appearance. The ordinary male and female plants are representative of the dioecious types.

Female.—The flowers are borne on short stalks, 1 to 3 inches in length, in the axils of the leaves, and are characterized by the absence of stamens. The fruit may be oval, pear-shaped or practically round.

Male.—The typical male or staminate tree produces its flowers in clusters on long pendulous flowering branches. Each flower usually has ten stamens and an abortive pistil. Under certain climatic conditions the pistil may on occasions develop normally and the male tree may bear a few fruits, which are usually cucumber-shaped.

Hermaphrodite.—The ordinary hermaphrodite tree is typical of the monoecious types, which may produce various combinations of male, female, and perfect flowers. (Perfect flowers are characterized by a well-developed pistil and stamens). Cucumber-shaped fruits are usually produced; but round, pear-shaped, or irregular fruits may occur in the same cluster with the first type.

The marked variation in the shape of the fruits on the same tree, and the low yield, are the chief objections against the growing of hermaphrodite trees on a commercial scale. The fruit of the female is fairly uniform and

* By Dr. J. D. J. Hofmeyr and J. C. le Roux, Horticulturists, Sub-tropical Horticultural Research Station, Nelspruit, in *Farming in South Africa*, Vol. XIV., No. 161, August, 1939.

differs usually only in size, which characteristic, coupled with a good yield, makes the female the most desirable type to grow. It is dependent on the male, however, for the pollination of its flowers, such pollination is essential for the subsequent normal set and development of the fruit of the female tree. Since the fruit produced by the male may be regarded as inferior, the only necessary function of the male is to produce pollen for pollination purposes.

CLIMATIC REQUIREMENTS

The papaw is a heat-loving plant and is very susceptible to frost. In South Africa it thrives best in a sub-tropical climate as exists mainly in the eastern Transvaal lowveld and Natal, but is also grown in certain frost-free areas of the eastern Cape Province. Though atmospheric heat is conducive to fruit development and quality, sunburn does much damage to fruit that is exposed as a result of leaf reduction through frost, wind or other adverse conditions.

Strong winds carrying sand and grit may injure the tender skins of immature fruits, causing the white milky juice (papain) to ooze through the injuries. Such damage renders the fruit unsightly and impairs its keeping qualities. It becomes necessary, therefore, to consider such factors as natural and artificial protection (windbreaks) against wind and frost when a site for planting papaws on a commercial scale is selected.

Under climatic conditions of high relative humidity and comparatively high atmospheric temperatures, papaws thrive but the fruits may not colour up sufficiently when reaching maturity and may remain pale green. Notwithstanding the excellent eating-quality of the ripe fruit, the lack of colour will affect the market price adversely. Experiments have shown, however, that colour may be improved by selection.

SEED AND SELECTION

Since the papaw is cross-pollinated, the progeny is usually very variable, and therefore it is of the utmost importance for the grower to obtain his seed from a reliable source where selection has been in operation for a number of years. If such seed is not available, the grower must select seed only from the best trees, attention being paid to the following points.—Vigour of trees; size and shape of fruit; colour of ripe fruit; thickness of flesh; quality, yield and optimum spacing of the fruit on the stem so that the shape of the fruit is not affected by overcrowding. The crop produced as the result of the first selection will necessarily be variable, but if the grower persists with this selection program he will be rewarded by an increasingly greater uniformity of the crop after each successive generation. This procedure has already been practised by some growers with considerable success.

It should be mentioned here that the senior author has already made considerable progress in the breeding of desirable and true-breeding papaw varieties. Small quantities of seeds of these strains will probably be available for distribution to farmers after another two to three years of experimentation.

SOWING OF THE SEED

Seedlings may be raised either in beds, in trays, or a combination of these two methods may be used.

Seed-beds.—A good bed should be prepared in the usual manner. The best time to sow the seed is from September to December. The beds are first watered thoroughly, and then shallow furrows, ½ inch deep and 9 inches apart in which the seeds are sown ¼ to ½ inch apart, are made across the bed. Cover the seeds lightly with soil, and water again. To prevent crust-formation, a thin layer of river-sand may be added and it is also advisable to shade the beds with grass or hessian. In order to control damping-off, which is a very troublesome disease when the plants are in the seedling stage, the beds should be well ventilated and not watered during the heat of the day. Some time after germination the seedlings are thinned out to allow a spacing of 2 to 3 inches between them in the row. If the surplus plants are lifted carefully they may be transplanted to an empty bed.

It is important to harden the plants before transplanting, by exposing them to the sun gradually and by watering them sparingly. The hardening-off process should start after the plants are approximately 4 inches in height. If the seedlings are inclined to become spindly, they may be topped a few inches above ground level. The seedlings are ready to be transplanted when they are 6 to 9 inches high. This stage is reached about 2½ months after the sowing of the seed. A few days before the seedlings are transplanted most of the leaves should be trimmed off. Irrigate the beds thoroughly shortly before transplanting in order to facilitate the lifting of the plants, which should then be taken out carefully and wrapped in wet sacking to minimize injury to the roots through exposure.

The disadvantage of this method is that unless climatic conditions are favourable the mortality of the transplants is usually comparatively high. A method which has been practised by a number of growers to lessen the mortality of transplants, and which has met with considerable success, is described in the following paragraph.

A tin can with the bottom removed, or a similar implement, is put around the seedling to be transplanted, and pushed downwards until the top of the can is level with the soil surface. The plant, together with the tin, is now lifted—there being no danger of disturbing the soil around the roots—and is then taken to the field. Here the tin is put in the required place and the plant together with the soil, is removed by exerting pressure on the soil in the tin. For an effective operation of this method it is necessary to have the plants well spaced in the bed.

Seed-trays.—Since papaw seedlings are especially susceptible to damping-off shortly after germination, the sowing of seed in trays is practicable only where this disease is not troublesome. It should be mentioned here that experiments have shown that conditions in trays are more favourable for the development of damping-off fungi than in beds. Where seedlings can be raised successfully in trays they may be transplanted at an earlier stage than those raised in beds. The result is a low mortality of transplants even under comparatively unfavourable conditions.

Seed-beds and Seed-trays.—A method combining the advantages of the growing of seedlings both in beds and in trays eliminates most of the objections against either practice. Sow the seeds in beds in the usual manner, and transplant the seedlings to trays when they are about 3 inches in height. Most of the leaves should be removed on the previous day and the beds well watered to facilitate the lifting of the plants. A tray, the size of a halved paraffin tin, has sufficient room for 30 seedlings. Water well and shade the trays for about ten days until the seedlings have become established. They are then gradually exposed to the sun and the amount of watering is reduced for approximately ten days prior to transplanting. The seedlings are ready to be transplanted three weeks after they have been set in the trays. We have found that very few plants are lost when this method is employed.

Strong tins may be cheaply constructed from sheets of galvanized iron.

INITIAL PREPARATION OF SOIL

Though the papaw will grow fairly well on soils of low fertility, growers are warned against the tendency to produce this crop under such conditions. For the best results, a soil rich in plantfoods is necessary and if the soil is deficient in any plantfood constituent, suitable fertilizers should be added.

The soil should be well prepared by ploughing and discing to obtain the required friable condition. To facilitate irrigation, the layout should be such that the rows will be on the contour allowing a regular slope to 1 to 2 per cent. The planting holes, approximately 2 feet in diameter and 2 feet deep, should be spaced 10 feet on the square. About 1 to 2 months prior to planting, apply one bucket of well-rotted kraalmanure and $\frac{1}{4}$ lb. superphosphate to each hole, and mix well with the soil.

TRANSPLANTING AND THINNING

Since, on the average, about 50 per cent. of the seedlings are males, that is, unproductive trees, it is necessary to plant 3 to 4 seedlings, one foot apart, in each planting hole. Transplant only on cool and cloudy days or preferably in rainy weather. The planting holes should be watered shortly before and immediately after the setting out of the plants. If possible the transplanted seedlings should be protected against the sun by means of grass shelters, until they have become established.

As soon as the plants start to flower they are thinned out to one, and occasionally to two, per planting hole, in such a manner that there will be approximately one male to every 20 females in the final stand. This ratio of males to females is necessary to provide adequate pollination for normal fruit development. Under favourable conditions ripe fruit may be picked off a tree one year from the time of the sowing of the seed.

CARE OF ESTABLISHED PLANTS

Established papaw plants are comparatively drought-resistant. However, to ensure high yields and sound fruit, and to protect the fruits against sunscald, good leafgrowths should be encouraged by judicious irrigation. Some

growers believe that the quality of the fruit is impaired by irrigation during the winter months. This notion is, however, not supported by the results of our experiments and is apparently not well founded, when factors of low yield and sun-scald, as a result of reduced foliage due to lack of soil moisture, are taken into consideration. The frequency of irrigation during the dry period will depend on soil and climate and the size of the trees. In general, an irrigation every 2 to 3 weeks will be sufficient.

In our experiments, basin-irrigation has given excellent results. The basins are constructed around the trees and enlarged as the plants grow bigger, so that the whole root-zone area can be irrigated thoroughly.

The fertilizer program will depend on such factors as natural soil fertility, nature of previous fertilizer application, previous crops grown, and the condition of the plants. However, the following recommendations should serve as a general guide for fertilizer application.

As soon as the plants have become established, a light top-dressing of quickly-available nitrogenous fertilizer such as nitro-chalk, sodium nitrate or ammonium sulphate, should be given and its application repeated two months later. Under average conditions, an annual application of approximately 10 tons of kraalmanure and 700 to 800 lb. of superphosphate per morgen should keep the soil fertility at the required level.

During the summer months, a cover-crop such as sunnhemp can be grown between the rows. This will help to remove excessive soil moisture during the rainy season, will control weed-growth, and will maintain the organic matter and nitrogen content of the soil.

Root-cutting is harmful, and discing should therefore be resorted to instead of ploughing. Do not disc too deeply or too close to the trees when fertilizers or cover-crops are incorporated with the soil.

HARVESTING, PACKING AND MARKETING OF THE FRUIT

The harvesting season usually starts in April and may last until the end of December, with the peak during September and October. In cooler climates the initial ripening of the fruit may be delayed till spring, in which case the picking season may extend to January or February. Under favourable growing conditions brought about by factors such as judicious irrigation during the dry season (May to September), a high soil-fertility level, and other cultural practices, the plants may continue to flower and set fruit, and thus serve to prolong the marketing season, within limits. Yields may vary from 20 to over 150 fruits per tree, depending on climate and soil.

The stage at which papaws are to be picked will depend chiefly on the distance from the market and the season. Midwinter fruit should be picked at a much later stage than spring or summer fruit, because of the marked effect temperature has on the speeding-up or retarding of the ripening process subsequent to picking. Fruits picked too early do not develop the required flavour, texture and colour, whereas fruit picked at too mature a stage will lack keeping quality. The best guide is to pick at the latest stage possible for the fruit to reach the consumer in a sound condition.

In order to reduce wastage, the fruit should be handled carefully during havesting, transport and packing. The use of picking-gloves will minimize fruit injuries during picking, and will also protect the picker's hands against the milky juice of slightly immature fruits. Such juice, owing to its strong digestive action, may in the long run cause considerable discomfort. The picked fruit is placed in woodwool-lined lugboxes and carted to the packhouse to be graded and packed.

The number of fruits per standard papaw box measuring 18 in. by 12 in. by 6 in. varies from 4 to 7 (depending on size). Medium-sized fruit which allows the packing of 6 fruits per standard box is preferred. It is important that the fruits packed in the individual boxes should be at the same stage of maturity. Papaw boxes must be limed with woodwool, and the fruit packed firmly in woodwool with a thin layer of woodwool placed on top before the lid is put on. For sending to distant markets, it is preferable to wrap the individual fruits in ordinary large-sized fruit wrapping paper.

For marketing under the National Mark Scheme, the following regulations should be observed :—

Papaws must be graded as follows :—

1. (*a*) *First Grade.*—Papaws must be free from blemishes, injuries and bruises. Fruits packed in the same box must be at the same stage of ripeness, uniform in size and of one variety only. Fruits must not be too green or too ripe, and the flesh must be firm.

(*b*) Fruit must not vary more than 5 per cent. from the foregoing requirements in respect of condition and external appearance.

2. (*a*) Only new and clean boxes must be used.

(*b*) The boxes must be of the following external dimensions : length 18 in., width 12 in., depth optional.

3. (*a*) Papaws must be packed wrapped.

(*b*) Boxes must be packed to full capacity.

(*c*) Fruit showing signs of any disease must not be packed under the National Mark.

(*d*) The count must be clearly marked on the boxes.

Further particulars in this connexion may be obtained from the Bureau of Domestic Markets, P. O. Box 8,045, Johannesburg.

PAPAIN

The milky juice which exudes from green fruit when the skin is lanced contains the ferment papain, which is considered to be a very valuable ingredient in medicine as a remedy for certain digestive troubles.

In the light of the unpublished investigations of H. van Elden of the Subtropical Horticultural Research Station, Nelspruit, and the experience of other workers, the procedure for the extraction and drying of papain may be briefly summarized as follows :—

Contrary to the general conception that non-metallic knives should be used when lancing the fruit for the extraction of the milky juice, it was found by van Elden and others, that special steel knives may be used without discolouring

the latex. A steel-bladed knife has the advantage that a clean light incision can be made rapidly, without getting any of the green chlorophyll in the exuding juice.

The latex containing the papain is best obtained from full-grown, or nearly full-grown, well-developed green fruit by making 2 to 4 longitudinal incisions not more than ⅛ in. deep. This operation may be repeated every 3 to 7 days. It has been found that better yields are obtained if only a few incisions are made at a time, the tapping being done over a long period until the fruit is covered with incisions approximately 1 cm. apart. The flow is most abundant in the early morning. Very young fruits give a latex that is rather weak in digestive power, while ripe fruits give very little, if any, milky juice. In South Africa we have a more or less definite period, from February to August, for tapping.

Only non-metallic containers, such as glass or porcelain dishes, should be used to collect the latex, because the juice acts on the metal and becomes discoloured. Coagulation soon begins and the mass adhering to the surface of the fruit must be carefully scraped off. Considerable time and labour would be saved if a convenient and efficient vessel could be devised which could be quickly put in place to receive the juice, permitting the operator to proceed to the next tree in the meantime.

The juice must be dried promptly after it is collected or decomposition, which destroys the value of the product, will occur. Sun-drying is practised to some extent, but it is much more satisfactory to dry the latex in a properly ventilated oven operated at 50 to 55° C.

One form of drier is about 3 feet broad, 3 feet deep, and 6 feet long. The sides and ends are made of brick, and openings are provided at both ends, one for the flue and the other to admit fuel. A foot from the top, which is open, a sheet of iron is placed, and upon this one or two inches of sand are laid to modify and distribute the heat arising from the fire beneath. The coagulated juice is spread upon brown linen stretched upon frames, which are made to fit the top of the drier. The temperature should not exceed 50 to 55° C., since great heat destroys the ferment. The dry and flaky material can be ground in a coffee-mill, preferably when the material is warm, and it should then be in the form of a light cream-coloured powder, this powder should be placed in bottles, which should be tightly sealed.

Little information is available as to yields. Amounts of papain extracted per plant vary considerably; 20 to 250 grams per tree, or from 60 to 350 lb. of dried latex powder per morgen may be produced. Coagulated latex produces 25 per cent. of its weight of dried powder. The latex is harvested through three seasons. By the fourth season the fruit is so high on the trunk that the cost of collecting the juice becomes prohibitive.

The price of the crude product is in the neighbourhood of 10*s.* per lb. It is a debatable point whether the production of papain is South Africa will be a paying proposition. Factors which will decide this favourably are cheap labour and high yields. The lancing operation, though it does not affect the quality of the ripe fruit, renders such fruit unsightly and hence unmarketable.

Such fruit is valuable in processing, since quality only, and not outward appearance, is the chief consideration here. It is considered that the collection of papain may become a profitable sideline in this and other countries, provided that it can be produced in conjunction with the manufacture of other by-products such as canned fruit pulp, conserve, butter, chutney, jelly, &c.

USES OF THE PAPAW

According to Livingstone, the leaves, stems, roots and fruits of the papaw, can be put to fifty different uses of which only fifteen have so far been utilized. The fruit may be canned—as butter, chutney or jelly—be crushed for soda fountain use, or used as ice-cream flavouring or for syrups. The ripe fruit is frequently used in fruit salads or cooked as a vegetable. Rind and seed are processed for sale as a pickle relish. It is said that tough meat may be rendered tender by cooking it with green papaw fruit, or wrapping it in crushed papaw leaves. The fruit contains vitamins A, B, C and D which are vital for health.

The following recipes are given by Pope :—

Papaw Cocktail.—Cut papaw in dice or balls and serve in glasses with cocktail sauce and chipped ice. Or serve in the same manner with orange, lemon or lime juice, and a little sugar.

Papaw Whip.—To 1½ cups of papaw pulp, add juice of 1 lemon, ½ cup sugar and beat into 2 stiffly-whipped whites of eggs.

Papaw Pickle.—Make syrup of 1 measure sugar and ½ measure vinegar. Add a few whole cloves and peppercorns and 2 measures of half-ripe papaw cut into small pieces. Boil until tender.

Orange and Papaw Butter.—To 1 measure papaw allow ½ measure oranges. Wash oranges well. Squeeze out seeds and juice. Put skins through a meat chopper and add to the juice, strained free from seeds. Add papaw pulp cut in small pieces (without rind) and boil all together ; then add as much sugar as pulp. Boil again for 15 to 20 minutes.

Baked Papaw.—Cut papaw in halves lengthwise. Add a little sugar and orange, lime or lemon juice, or a little cinnamon in place of the juice. Bake 20 minutes and serve immediately on taking from the oven. This is a vegetable.

Green Papaw Preserve.—Cut the fruit into slices. Peel and prick well on all sides. Cut into required sizes, put into lime water (1 tablespoon lime to 12 cups water) and leave overnight. Drain and place the fruit in a boiling syrup made of equal quantities of sugar and water. (Allow 1 lb. of sugar for every 1 lb. of fruit). Boil until the fruit is transparent and the syrup of the right consistency.

Green Papaw (Vegetable).—Papaw, as a vegetable, is not unlike vegetable marrow. The papaw must be very green, *i.e.*, the flesh still quite white. Boil rapidly. When tender, strain, mash or leave in little cubes. Add butter and salt to taste.

INSECT PESTS AND DISEASES

Fortunately, the papaw has very few enemies. Insect pests are of minor importance and these will therefore not be mentioned here.

There are only two papaw-diseases that are of any consequence in South Africa, and these are described below.

Foot-Rot Disease.—The general symptoms of this disease are the following :—A marked reduction in growth vigour of mature plants, resulting in a yellowing of the leaves and, in extreme cases, complete defoliation. Examination of the base of the trunk will reveal that rotting of the stem slightly above and below ground-level has started. According to Wager the disease, which is caused by a Pythium fungus, becomes evident when the plant is subjected to unfavourable growth conditions such as poor drainage and poor soil fertility. When these unfavourable factors are remedied, the disease may be easily controlled.

The Pythium fungus is sometimes very troublesome in seed beds where it may cause damping-off of the seedlings. To control damping-off, it is advisable to sow the seed in clean soil, if possible ; water only in the early morning or late in the afternoon, and provide good ventilation.

Stem Rot (Anthracnose).—The Plant Pathologist at the Sub-tropical Horticultural Research Station, Nelspruit, states that this disease appears in three stages on the papaw, *viz.*, on the fruit, causing a rot in black round spots from ¼ to 3 inches in diameter ; on the petioles ; and on the trunk. Infected petioles will remain attached to the tree after maturity, whereas healthy ones will fall off. The fungus may gain entry into the stem through such infected petioles. The rotting of the stem due to anthracnose differs from that caused by Pythium (described above) in that the infection in the case of the former is usually well above ground-level, whereas in the latter case it is at or just under ground-level.

The following are control measures. Remove and burn infected petioles ; if the infection is bad the trunks may be sprayed with a 4–4–50 Bordeaux mixture ; in severe cases the infected portion is cut away and painted with Bordeaux paste, which is made by mixing Bordeaux powder with raw linseed oil.

Any further information relating to the culture of the papaw may be obtained from the Chief Horticulturist, Box 994, Pretoria. Those who desire advice in connexion with (1) diseases of the papaw, and (2) insect pests attacking papaws, should communicate with (1) the Principal Plant Pathologist, Box 994, Pretoria, and (2) the Chief Entomologist, Box 513, Pretoria, respectively.

MEETINGS, CONFERENCES, &c.

REPORT OF THE PROCEEDINGS OF THE SIXTH MEETING OF THE CENTRAL BOARD OF AGRICULTURE.

THE sixth meeting of the Central Board of Agriculture was held in the Board Room of the Department of Agriculture at 2.30 P.M. on Thursday, July 20, 1939.

Mr. E. Rodrigo, C.C.S. (Acting Director of Agriculture and Chairman of the Board) presided, and the following members were present :—Sir Wilfred de Soysa, Messrs. H. W. Amarasuriya, M.S.C., S. F. Amerasinghe (Sr.), S. Armstrong, C. Arulambalam, W. H. Attfield, A. C. Attygalle, N. J. Bannerman, R. H. Bassett (Commissioner for Development of Agricultural Marketing), A. Canagasingham, Dr. Reginald Child (Director, Coconut Research Scheme), Messrs. V. Coomaraswamy (Acting Conservator of Forests), M. Crawford (Deputy Director, Animal Husbandry, and Government Veterinary Surgeon), E. C. de Fonseka (Jr.), C. N. E. J. de Mel (Principal, Farm School), George E. de Silva, M.S.C., G. de Soyza (Acting Registrar of Co-operative Societies), L. Bandara Dharmakirti, James P. Fernando (Chairman, Low Country Products Association), James Forbes (Jr.), Dr. J. C. Haigh (Botanist), Mr. L. L. Hunter, Dr. J. C. Hutson (Entomologist), Dr. A. W. R. Joachim (Chemist), Messrs. A. L. Johnpulle (Acting Agricultural Officer, Plant Pests), R. C. Kannangara, M. S. C., S. M. K. B. Madukande Dissawe, T. H. E. Moonemalle, Mudaliyar S. Muttutamby, Dr. R. V. Norris (Director, Tea Research Institute of Ceylon), Mr. T. E. H. O'Brien (Director, Rubber Research Scheme), Dr. S. C. Paul, Messrs. Marcus S. Rockwood, B. M. Selwyn, Rolf Smerdon, R. H. Spencer-Schrader, S. G. Taylor (Acting Director of Irrigation), U. B. Unamboowe, Mudaliyar N. Wickramaratne, Rev. Father L. W. Wickramasinghe, Messrs. C. L. Wickremesinghe (Commissioner of Lands), C. Huntley Wilkinson, and Mr. Malcolm Park, Secretary.

The following visitors were present :—Messrs. Wace de Niese, J. P. A. D. Fernando, P. T. Jinendradasa Dr. A. Nell, Messrs. W. M. Rogers, and G. V. Wickramasekera.

The following members intimated their inability to attend the meeting : Messrs. M. M. Ebrahim, Wilmot A. Perera, and A. A. Wickramasinghe.

CONFIRMATION OF MINUTES.

The draft minutes of the fifth meeting of the Board, held on March 17, 1939, were amended and confirmed.

PERSONNEL OF THE BOARD.

The Chairman announced that Mr. W. H. Attfield had been nominated as the representative on the Board of the Ceylon Estates Proprietary Association in place of Colonel T. Y. Wright, resigned. He welcomed Mr. W. H. Attfield on behalf of the Board.

The Chairman intimated that Mr. C. Huntley Wilkinson would shortly be leaving Ceylon and expressed, on behalf of the Board, thanks to him for his able services as a member of the Board and of its Executive Committee.

ACTION TAKEN ON THE DECISIONS OF PREVIOUS MEETINGS OF THE CENTRAL BOARD OF AGRICULTURE.

The Chairman read a statement of the action that had been taken on motions passed at the fifth and earlier meetings of the Board.

The following is a summary of the statement :—

(1) *Soil Erosion.*—No decision has yet been reached on the report of the Soil Erosion Committee and the question of the office of Soil Conservation Officer.

(2) *Tea tortrix.*—The regulations regarding the collection and destruction of tea tortrix have been rescinded.

(3) *All-Island Agricultural Shows.*—It is hoped that, if the necessary funds are made available, the first show will be held in about May, 1940.

(4) *A five-year plan of irrigation policy and the control of all colonization work by the Department of Agriculture.*—The resolutions relating to these are under consideration by the Hon. the Minister for Agriculture and Lands.

(5) *Premium-bull scheme.*—Provision for the payment of premia was included in the draft Estimates of the Department of Agriculture for 1939–40. In view of the financial stringency this item, among many others, has been deleted from the Estimates. It is hoped that it will be considered more favourably next year.

REPORT ON THE WORK OF THE BOTANICAL DIVISION.

The Chairman stated that he wished to introduce a new feature at the meetings of the Board. He felt that the work carried out by the different Divisions of the Department of Agriculture was not sufficiently well-known and he proposed, with the approval of the Board, to ask the heads of the different Divisions to give from time to time at meetings of the Board an account of work in progress. The Board approving the suggestion, the Chairman called on Dr. J. C. Haigh to give a short account of the work in progress in the Botanical Division.

(Dr. Haigh's report is published separately in *The Tropical Agriculturist*).

Mr. Marcus Rockwood inquired whether experiments had been carried out with derris root. Dr. Haigh replied that earlier experiments had shown that derris grew satisfactorily, but that the roots of the varieties tested had a low rotenone-content. A further consignment of derris had been imported from Malaya but the plants were as yet insufficiently mature for root examination.

AMENDMENTS TO IRRIGATION ORDINANCE.

The Chairman stated that the proposed amendments to the Irrigation Ordinance (Chapter 312 of the Revised (1938) Edition of the Legislative Enactments of Ceylon) had been referred to the Executive Committee for report. Copies of the report had been sent to all members. The Executive Committee had concluded that it was not possible to evolve a practicable method of protecting paddy fields and irrigation works ancillary thereto from damage by soil erosion without taking steps to prevent erosion on all land lying above such paddy fields and irrigation works. The Executive Committee felt that, as this was part of the major problem of soil conservation throughout the Island, it should be considered with the proposed Soil Conservation Ordinance.

The Chairman proposed from the Chair the following, based on the recommendations of the Executive Committee :—

"That the Central Board of Agriculture do request the Hon. the Minister for Agriculture and Lands to arrange for the early framing of a comprehensive Soil Conservation Ordinance and for the inclusion in that ordinance of the protection of paddy land from silting."

The proposal was carried unanimously.

FORMULATION OF A SCHEME OF FARMING AS A CAREER FOR EDUCATED YOUNG MEN.

The Chairman stated that the following resolution, proposed by Mudaliyar N. Wickramaratne at the fourth meeting of the Board, held in November, 1938, had been referred to the Executive Committee for the formulation of a scheme:—

"In view of the restriction now placed on the extension of tea and rubber planting industries, the absence of satisfactory prospects in the coconut planting industry and the general overcrowding of the learned professions in the Island it is the opinion of this Board that the Department of Agriculture should formulate and publish a scheme, or schemes, of farming as a career, for the information of the many young men who pass from our schools each year."

The Executive Committee had obtained from Mudaliyar N. Wickramaratne a memorandum on the subject. The Committee had considered this memorandum and had obtained from the Director of Agriculture relevant figures regarding the cost of clearing and opening land. Copies of the report of the Executive Committee had been sent to all members of the Board. It would be seen that the Executive Committee had reported that, on the basis of the detailed estimates prepared by the Department of Agriculture, the capital expenditure for the establishment of farms for educated young men would be so great that no scheme could be suggested by the Executive Committee which would not involve the prohibitive use of State funds.

The Chairman suggested that the Board might discuss the original motion again in the light of the suggestions made in the report of the Executive Committee or, alternatively, some member might move the adoption of the Executive Committee's report.

A general discussion followed in which members pointed out that they were not in a position to come to a decision on the matter without first seeing the memorandum submitted by Mudaliyar Wickramaratne and the estimates for the cost of clearing and opening land made by the Department of Agriculture.

Mr. C. Arulambalam proposed and Mr. S. Armstrong seconded that the matter be deferred for further discussion until the next meeting and that copies of the memorandum prepared by Mudaliyar Wickramaratne and of the estimates of expenditure prepared by the Department of Agriculture be sent to all members for consideration before that meeting.

The Board agreed to this proposal.

LEASING BY GOVERNMENT OF LANDS IN THE VICINITY OF ESTATES FOR FOOD PRODUCTION.

The Chairman stated that the following resolution, proposed at the fourth meeting of the Board, held in November, 1938, had been referred to the Executive Committee for report :—

> " That, with a view to supplementing the supply of food for labourers on estates in the event of food control being enforced, Government be requested to lease land—forest and stream reserves excepted—suitable for the growth of all kinds of indigenous foodstuffs, including vegetables, where available in the vicinity of estates."

Copies of the report of the Executive Committee had been sent to all members.

Mr. C. Huntley Wilkinson moved and Mr. Rolf Smerdon seconded the adoption of the report.

Mr. C. L. Wickremesinghe, Commissioner of Lands, stated that he had been unable to attend a meeting of the Executive Committee at which this matter had been considered. He pointed out certain difficulties that would arise if the report were accepted as it stood and suggested that the matter be referred back to the Executive Committee and that the Committee might give him the opportunity of helping them to submit more practical recommendations.

Mr. R. C. Kannangara supported this suggestion and, after further discussion, the Board agreed that the matter be referred back to the Executive Committee.

THE ERADICATION OF BUNCHY-TOP DISEASE OF PLANTAINS.

The Chairman stated that the following proposal of Mr. C. Arulambalam made at the fifth meeting had been deferred to enable the Board to consider a report from the Plant Pathologist on the subject :—

> " That as the Bunchy-top disease of the plantain is prevalent in all parts of the Jaffna District and as it is the cause of serious loss to the cultivators of that crop, which is one of the staple money crops next to tobacco of the Jaffna cultivator, and as it is beyond the means or the capacity of the average cultivator to eradicate the disease, the Central Board of Agriculture recommends to the Executive Committee of Agriculture and Lands to have the

necessary steps taken without delay, by providing the Agricultural Department with adequate funds and staff, to enable it to carry out the work of eradicating the disease from the District through planned and co-ordinated action."

The Chairman stated that copies of the report of the Plant Pathologist and of his own comments thereon had been sent to all members. In view of the fact that, although the motion had been proposed and seconded at the last meeting, the submission of these memoranda might affect the proposal, he felt that Mr. Arulambalam should be allowed to amplify the observations he made at the last meeting.

Mr. C. Arulambalam stated that it would appear from the memorandum of the Plant Pathologist that the complete eradication of the disease would take many years and would be very expensive. He felt that, if the Board considered that the cost of eradication was too high, it would be necessary for the Department of Agriculture to assist the plantain industry in controlling the disease aided, if necessary, by legislation. He asked for the views of the Board on the matter.

Mr. R. C. Kannangara stated that information regarding the cost of eradication in the Hambantota area was not available. He felt that the exact cost of eradication should be obtained in different centres, and that the policy adopted should be based on the results of experiments carried out for a number of years.

Mr. Marcus S. Rockwood inquired whether it was not true that the disease occurred in the West Indies and that it had been eradicated there. The Plant Pathologist replied that there had been no record of the occurrence of the disease in the West Indies.

Several members spoke of the importance of the disease and pointed out the necessity of taking steps to control it.

Mr. C. Huntley Wilkinson suggested that the campaign in Jaffna should be continued. If control measures were successful there, they could then be extended to other parts of the Island.

Mr. R. C. Kannangara moved the following amendment:

"That this Board do recommend that experiments for the eradication of bunchy-top disease of plantains should be conducted on ten-acre blocks in the Northern, Central, Western, Southern and North Western Provinces."

Mr. S. F. Amerasinghe (Sr.) seconded the amendment.

The Chairman stated that he felt that sufficient information regarding the control of the disease was already available. The main question which should be considered was that of cost. The expenditure involved in conducting an eradication campaign throughout the Island for about ten years would be enormous.

The amendment was put to the meeting and lost.

Mr. Arulambalam, in conclusion, stated that in view of the high cost he wished with the approval of the Board to withdraw his proposal. He recommended

the adoption of the suggestion that the control of disease should be encouraged by propaganda and by bringing to the notice of cultivators the importance and value of the control measures advocated.

The motion was therefore withdrawn. The Chairman undertook to adopt Mr. Arulambalam's suggestion.

THE PURCHASE OF LOCAL PADDY FOR USE IN A NATIONAL EMERGENCY.

Mudaliyar N. Wickramaratne moved :—

" That it is the opinion of this Board that Government should take steps to purchase local paddy for the purpose of reserving the same for use in case of any national emergency."

Speaking to his motion, Mudaliyar Wickramaratne said that it was very desirable that the cultivation of paddy in Ceylon should be extended. He understood that a stock of rice was to be purchased by Government for use in a national emergency. He felt that, if paddy were purchased locally at an economic rate, paddy cultivation would be encouraged.

Mr. A. C. Attygalle seconded the resolution.

A discussion followed in which it was pointed out that supplies of paddy could not be purchased without the possibility of causing a shortage of domestic paddy, as crops had failed in certain districts. In the circumstances it would be unlikely that sufficient paddy could be purchased locally to ensure an adequate reserve supply.

The motion was put to the meeting and carried.

THE GOVERNMENT RICE MILLING SCHEME.

Mudaliyar N. Wickramaratne moved :—

" That in the opinion of this Board the working of the Government rice mills should be handed over to an existing Ceylonese Company or to a Ceylonese company created for that purpose controlled and subsidized by the Ceylon Government."

Speaking to his motion, Mudaliyar Wickramaratne stated that he understood that the rice mills at Anuradhapura and those now being erected by Government in other parts of the Island were to be handed over to a foreign company. He thought that this was not in the best interests of the paddy industry in Ceylon.

Mr. S. Armstrong seconded the resolution.

Mr. R. C. Kannangara stated that Mudaliyar Wickramaratne's proposal was based on false information. There was no truth in the statement that Government was going to hand over the mills to a foreign company.

Mr. H. W. Amarasuriya felt that the motion was premature. He moved as an amendment :

" That, in the event of Government handing over the rice mills, it is the opinion of this Board that the mills should be handed over to an existing Ceylonese company or to a Ceylonese company created for that purpose controlled and subsidized by the Ceylon Government."

Mr. Kannangara seconded the amendment.

Mudaliyar Wickramaratne stated that he was prepared to accept the amendment.

The Chairman said that he felt that it was not proper for the Board to discuss, or advise the Government on a matter of public policy the object of which, however desirable in itself, is not the increased and improved production of agricultural goods. If the Board decided to support the proposal or the amendment this support would be given only if it was felt that by passing the resolution they were going to promote an increase in paddy cultivation.

The proposal as amended was put to the meeting and lost.

HANDBOOKS ON AGRICULTURAL PRODUCTS.

Mr. C. Arulambalam moved :

" That the Central Board of Agriculture recommends to the Department of Agriculture to publish, for sale at a moderate price, a series of handbooks in English and the vernaculars (Sinhalese and Tamil), written in simple language and setting out all the scientific information that can be known about the growing of different agricultural products, the information to be based both (*a*) on the experiments conducted by the Department in every one of its own Experiment and Demonstration Stations in the Island and (*b*) on the study, by Departmental Officers, of the methods and results of cultivation by private agriculturists throughout the Island, each publication to deal with one product only, the object of such publications being the encouragement of the scientific cultivation on up-to-date lines of the products in every part of the Island suitable for its cultivation."

In speaking to his motion, Mr. C. Arulambalam stressed the need for handbooks written in simple language for the guidance of cultivators.

Mr. S. Armstrong seconded the motion and said that existing journals like *The Tropical Agriculturist* and the two vernacular journals had a limited circulation and books were required which would reach every farmer.

The Chairman said that, as Director of Agriculture, he would willingly accept the resolution but he pointed out that the information available on certain crops was insufficient for a handbook. In such cases he presumed that other suitable publications might replace the handbooks.

Other members spoke in support of the resolution.

Mr. James P. Fernando asked that books on animal husbandry should be included and suggested that it was important that the language used should be as simple as possible.

The motion was put to the meeting and carried unanimously.

VINE CULTIVATION IN JAFFNA.

Mr. C. Arulambalam moved :

" The Central Board of Agriculture recommends to the Department of Agriculture that an early investigation be made into the causes which have led to the decline and threatened extinction of the vine-growing industry

in the Jaffna District, with a view to the resuscitation and possible expansion of that industry, which has been, for a long time, one of the minor agricultural industries in the District."

Mr. Arulambalam stated that he had little to add to what he said in his memorandum on the subject. The industry was declining and he felt that it was important that a competent authority should investigate the cause of this decline.

Mr. R. H. Bassett seconded the resolution.

Mudaliyar Wickramaratne asked that the investigation be extended to Kalpitiya where the same conditions prevailed.

The Chairman said that he would accept the resolution and would submit a report in due course.

RE-INTRODUCTION OF A CATTLE VOUCHER SYSTEM.

Mr. S. B. Madukande moved :

" That, in view of the large number of illicit sales and thefts of cattle now occurring consequent on the abolition of the Cattle Voucher system, this Board recommends to Government the early introduction of the old system of executing vouchers by headmen for all cattle transferred or sold and of preparing cattle lists annually for purposes of identification."

Mr. Madukande, in speaking to his motion, pointed out that the abolition of a cattle-voucher system had led to an increase in the number of cattle thefts. He understood that it was proposed to introduce a modified system of licensing. This, however, might take a long time and he felt that immediate action was necessary.

Mr. S. Armstrong seconded the proposal and stated that the necessary machinery for the re-introduction of the cattle-voucher system was available. He felt that the old system should be revived until the new regulations came into operation.

Mr. M. Crawford, Deputy Director, Animal Husbandry, and Government Veterinary Surgeon, said that the cattle-voucher system was abolished in 1936 in order to discourage unnecessary branding and to permit of free buying and selling of cattle. There had been an increase in the number of cases of cattle theft since that time and it was generally accepted that this increase was associated with the revoking of the regulations. There had, however, been a general increase in crime of all sorts in Ceylon during the same period. The Minister for Agriculture and Lands had under consideration the question of introducing modified regulations to check cattle-thefts. With the proposed new regulations registration of cattle would be optional and other undesirable features of the old regulations would be omitted. He suggested that, in the circumstances, Mr. Madukande might withdraw his motion until he saw if the new regulations were effective.

A general discussion followed at the conclusion of which the Chairman asked Mr. Madukande if he wished to withdraw his motion. Mr. Madukande desired that his motion should be put to the meeting.

This was done and the motion was lost.

THE COCONUT RESEARCH STAFF.

Mr. Rolf Smerdon asked the Board for permission to withdraw this item from the agenda.

Permission was granted.

COCONUT BEETLE.

Mr. Rolf Smerdon stated that this subject had been placed on the agenda at the request of the Planters' Association of Ceylon. He wished to draw the attention of the Board again to the serious situation prevailing in coconut growing districts on account of the number of dead palms, standing or fallen, which provided breeding places for the coconut black beetle and the concomitant pest, the red weevil.

Mr. Smerdon stated that the situation became serious in 1936 but at that time it was felt that the enforcement of the regulations would impose undue hardships on the villager and small-holder. In consequence, it was decided that a policy of education and persuasion should be tried. At the beginning the policy had met with some success. The situation had, however, deteriorated and at present there were large numbers of dead palms standing or felled or in use as fence posts. He felt that since growers had failed to take advantage of the policy of education and persuasion the time had come for corrective treatment. He therefore moved :

> " That owing to the prevalence of the Black Beetle and Red Weevil pests of the coconut palm, especially in the Kurunegala District, this Board considers that the Regulations regarding this pest, proclaimed under the Plant Protection Ordinance, Chapter 307 of the Revised Edition (1938) of Legislative Enactments of Ceylon, should be strictly enforced."

Continuing Mr. Smerdon suggested that the enforcement of the regulations should be proclaimed with the beat of tom-tom in every village and hamlet and that a short time afterwards prosecutions should be started. He felt that prosecution should be entered first against the owners of large estates and that the prosecutions should work downwards progressively. If this were done and if sufficient publicity given to the prosecutions, by the time the village was reached it would be necessary to search diligently to find any cause for action.

Mr. C. Huntley Wilkinson seconded the resolution.

The motion was put to the meeting and carried.

The meeting terminated at 5.35 P.M.

MALCOLM PARK,
Secretary, Central Board of Agriculture.

Peradeniya, August 21, 1939.

COCONUT RESEARCH SCHEME

BOARD OF MANAGEMENT.

MINUTES OF THE FORTY-SEVENTH MEETING OF THE BOARD OF MANAGEMENT, COCONUT RESEARCH SCHEME, HELD IN ROOM NO. 202, NEW SECRETARIAT, COLOMBO, ON FRIDAY, SEPTEMBER 15, 1939, AT 10 A.M.

PRESENT.

Mr. E. Rodrigo, C.C.S., Acting Director of Agriculture (in the Chair); Mr. C. H. Collins, C.C.S. (Treasury Representative); Mr. O. B. M. Cheyne; Mr. A. R. Ekanayake; Mr. James P. Fernando; Mr. D. D. Karunaratne, J.P.; Mr. G. Pandittesekera, J.P., U.P.M.; Mr. L. J. M. Pieris, M.B.E., B.A.; Mr. H. W. Peiris; Mr. E. R. Tambimuttu, M.S.C.

Dr. R. Child, Director of Research, acted as Secretary.

MINUTES.

The minutes of the previous meeting held on Tuesday, June 20, 1939, which had been circulated to members were confirmed.

BOARD OF MANAGEMENT.

The Chairman reported that Mr. S. Samarakkody, had been re-nominated by H. E. the Governor, as a representative of the State Council on the Board of Management with effect from August 13, 1939, for a period of three years.

STAFF.

The Chairman reported that all papers in connection with the Geneticist's study leave had been circulated. It was agreed that Mr. Pieris after arrival in Trinidad should, in consultation with the Principal, Imperial College of Tropical Agriculture, draw up a scheme of further travel and forward it to the Board together with a statement of cost and the objectives he hopes to achieve by his travels.

The extension of the agreement in connection with the Geneticist's study leave was tabled and approved.

FINANCE.

Statement of Receipts and Payments.—The statement of Receipts and Payments for the quarter ended June 30, 1939, was tabled and approved.

In connection with travelling, Mr. L. J. M. Pieris raised the question of advisory visits to estates. He thought that there was a tendency on the part of some of the public to expect officers of the Scheme, particularly the Soil

Chemist, to visit and give general reports on their estates. He considered that this was not work which could be expected of the Scheme. The Director of Research said that the Ordinance laid down as one of the duties of the Board that

> "The Board shall, by the provision and publication of information, as well as by advice and demonstration and the inspection of plantations, give practical assistance to persons engaged in the coconut industry."

This instruction was of a somewhat general nature, but in his view the Scheme's officers should only be expected to advise on specific matters, such as manuring, &c., He agreed with Mr. Pieris that the Scheme should not be expected to do *gratis* the work of Visiting Agents, as many inquirers seemed to suppose. The Rubber Research Scheme had, he understood, issued a circular laying down the conditions under which their officers would visit estates, and he considered that it would be useful if the Coconut Research Scheme did the same.

The Director of Research was instructed to report to the Board on this subject.

DRAFT MEMORANDUM ON THE FUTURE OF THE COCONUT RESEARCH SCHEME.

The Chairman referred to the discussion on the future position of the Scheme which took place at the previous meeting and said that a detailed memorandum prepared by the Director of Research had been circulated. Copies of this memorandum had also been made available to the members of those bodies which were represented on the Board of Management, *viz.*, the L.C.P.A. and the Planters' Association of Ceylon. The latter body had referred it to the District P.A.'s of Chilaw, Kurunegala, and Galle, and the first named two associations had discussed it at special meetings. Individual notes on the memorandum had also been received from the Deputy Financial Secretary and from Mr. G. Pandittesekera.

Mr. James P. Fernando said that the L.C.P.A. had not been able to complete their deliberations and asked whether consideration could not be postponed.

The Chairman said that the Deputy Financial Secretary had stated that "in view of the outbreak of war, it would seem impossible to settle the future policy of the Board now, and it would seem preferable to carry on as well as we can for the present, leaving the formulation of a new scheme till the future is clear.

In view of the importance of the coconut industry to the Island as a source of food supply, and also as a source of material likely to be required for the war, and in view of the desirability of carrying on as well as we can all local industry, the Scheme should be kept going during the war.

I consider that it is too early to be able to decide whether the industry will be in a position to pay an increased cess. We should in my opinion address Government and ask for a continuance for the present of the grant now given."

Mr. Collins added that the memorandum was a useful one and if the circumstances of the Industry were such in the future that it could meet an increased cess some of the proposals might be considered.

The Board agreed to defer indefinitely any proposals for increased cess or alteration of the present financial arrangements, and decided that Government should be approached for a temporary continuance of the existing grant. With regard to the Estimates for 1940, therefore, the Director of Research was instructed to frame these on normal lines with the utmost economy under all heads of expenditure.

ESTATES.

In the course of discussion of the Estate Reports, the Director of Research mentioned that both the Tea Research Institute and the Rubber Research Scheme employed visiting agents for their estates and suggested that the Board might like to consider following the same procedure. He would himself welcome the appointment of a visiting agent as he thought it would be useful to have independent reports on the working of the estate. It was decided to take up the question at a later meeting.

Mr. James P. Fernando raised the question of price of seednuts and seedlings and expressed the view that the usual price of seednuts was too high.

Mr. L. J. M. Pieris did not think it necessary to make a change, as all seednuts available found a market, and further he thought it a good policy to set a high standard which we gave encouragement for estate owners to take up palm selection with a view to themselves supplying selected seednuts.

It was decided to make no change at present, but that the Director of Research should report on the subject so that the Board might review the whole position.

The Progress Reports were then approved.

Mr. S. R. K. MENON.

Progress Report.—A report on the work of Mr. Menon for the period May 1 to July 31, 1939, had been circulated to the Board and had also been sent to the Coconut Board.

It was decided that, as in previous cases, the Board of Management, Coconut Research Scheme, had no objection to publication of the reports, and the Coconut Board should be so informed.

The Chairman said that he understood the position with regard to Mr. Menon's work was that it was not considered possible to manufacture superior grades of paper, such as writing paper in Ceylon.

The possibility of making wrapping paper and boards was, however, more promising and the Director of Research reported that Mr. Menon expected to be able to make more definite statements in his next report, which was due on November 15, 1939. The Board expressed the view that Mr. Menon could continue to work at Bandirippuwa at least until the end of the year.

MISCELLANEOUS.

Daily-paid Non-Ceylonese Labour.—In accordance with the decision of the Board at the previous meeting completed forms for each individual non-

Ceylonese labourer employed at Bandirippuwa and Ratmalagara estates were tabled. It was decided to ask the Chairman to examine these and advise the Board of Management at the next meeting.

OTHER BUSINESS.

Acetic acid.—The Chairman drew attention to the inflated price of acetic acid and said that the Director of Research had already considerable information on the possibilities of local production from coconut shells. Some laboratory samples were tabled by the Director of Research.

The Deputy Financial Secretary thought that it was a matter which should be proceeded with at once, though care should be taken not to overlap with the work of other Departments. He suggested that the Chairman should be given a free hand to authorize work and expenditure in connection with the subject, and that the Director of Commerce and Industries and others interested in the matter should be consulted. The Board agreed.

NEXT MEETING

It was decided to hold the next meeting in Colombo, on October 11, 1939, at 10 A.M.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED SEPTEMBER 30, 1939

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1939	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Rinderpest	9	..	..	2	..	7
	Anthrax	12	..	10	2	..	..
	Rabies	2	..	..	..	..	2
	Piroplasmosis	5	1	..	4	1	..
	Haemorrhagic Septicaemia	3	..	3	..	..	..
	Blackquarter	1	..	1	..	..	..
Colombo Municipality	Foot-and-mouth disease	33	..	3	29	..	1
	Anthrax	1	..	1	..	..	..
	Rabies	2	..	2	..	..	..
	Piroplasmosis	6	..	1	5	..	..
Cattle Quarantine Station	Foot-and-mouth disease	2	..	..	2	..	..
	Anthrax	29	..	29	..	..	..
Central	Foot-and-mouth disease	437	80	1	360	76	..
	Anthrax	5	..	5	..	..	..
	Rabies	9	1	2	..	..	7
	Contagious mange	18	..	2	16	..	..
	Blackquarter	9	..	8	..	..	1
	Piroplasmosis	10	..	2	8	..	..
Southern	Foot-and-mouth disease	665	5	31	630	4	..
	Rabies	5	3	..	..	..	5
	Haemorrhagic Septicaemia	4	..	4	..	..	..
Northern	Foot-and-mouth disease	130	..	7	123	..	..
	Rabies	1	..	..	..	..	1
Eastern	Foot-and-mouth disease	5	..	..	5	..	..
	Anthrax	48	6	48	..	..	..
North-Western	Foot-and-mouth disease	122	..	3	119	..	..
	Contagious Mange	18	..	..	18	..	..
	Rabies	11	5	2	..	..	9
	Piroplasmosis	1	1	..	1	..	..
	Haemorrhagic Septicaemia	23	23	23	..	..	..
North-Central	Foot-and-mouth disease	1,695	..	10	1,685	..	..
	Blackquarter	31	4	31	..	..	..
Uva	Foot-and-mouth disease	114	13	4	97	13	..
Sabaragamuwa	Haemorrhagic Septicaemia	1	..	1	..	..	..
	Rabies	5	3	..	..	..	5

Department of Agriculture,
Peradeniya, October 19, 1939.

M. CRAWFORD,
Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, SEPTEMBER, 1939

STATION		TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
		Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	DAY	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
		°	°	°	°	%	%		Ins.		Ins.
Colombo	..	85·7	+0·6	77·1	+0·6	75	86	7·2	4·97	16	— 2·04
Puttalam	..	87·6	+1·3	78·4	+0·9	72	84	6·5	0·18	1	— 1·61
Mannar	..	88·0	+0·1	79·1	+0·4	74	85	8·7	0·33	1	— 1·00
Jaffna	..	86·8	+1·0	79·6	+0·6	77	82	5·4	1·24	5	— 1·85
Trincomalee	..	93·2	+1·8	77·8	+1·1	62	80	6·2	2·97	6	— 0·85
Batticaloa	..	90·4	+0·8	76·9	+1·1	64	82	4·2	0·20	1	— 2·35
Hambantota	..	87·7	+1·5	77·0	+1·1	74	86	5·5	1·20	6	— 1·86
Galle	..	82·9	+0·1	78·2	+1·5	76	80	6·7	4·46	13	— 5·94
Ratnapura	..	87·4	+0·3	73·8	+0·4	74	93	7·1	13·25	18	— 3·03
Anuradhapura	..	91·6	+0·7	74·8	0	63	93	7·0	2·20	3	— 1·71
Kurunegala	..	87·4	—0·1	74·5	+0·4	70	90	6·0	4·61	13	— 1·56
Kandy	..	84·2	+0·3	69·1	—0·1	72	90	7·0	4·44	15	— 2·15
Badulla	..	85·8	+0·3	65·2	+1·1	59	92	5·0	6·58	8	+ 2·10
Diyatalawa	..	78·7	+0·9	60·3	—0·5	60	80	6·2	3·17	7	— 1·23
Hakgala	..	70·5	+0·4	55·0	—1·7	78	91	6·0	4·71	16	— 1·86
Nuwara Eliya	..	67·1	+0·2	52·1	—0·9	79	91	7·9	5·84	20	— 3·09

The rainfall for September, though below average over the greater part of the Island, did not show marked departures from normal. A few stations, particularly in the central hill-country, recorded slight excesses. Deficits of over 5 inches were common in the Galle District, the largest being 6·81 inches at Hiniduma and 6·18 inches at Batapola. The largest excesses were 8·92 inches at Helboda and 7·88 inches at St. Andrew's, Nawalapitiya.

The highest monthly totals reported were 28·64 inches at Watawala, 28·11 inches at Norton Bridge and 25·70 inches at Ingoya.

About 22 stations, distributed in the northern half of the Island, recorded no rain at all during the month.

Only 4 cases of daily falls of over 5 inches were reported, the largest being 7·15 inches at Medagama on the 16th.

During the first week of the month, settled weather prevailed with little or no rain. A weakening of the south-westerly pressure gradient on the 8th resulted in some irregularly distributed local thunderstorms. Very little rain fell between the 9th and the 12th. From the 13th until the end of the month rain more or less persisted in the south-west of the Island. Rain was fairly heavy on the 19th, 23rd, and 25th.

Temperatures were on the whole slightly above average. Humidity was generally below normal, while cloud amounts were distributed irregularly on either side of average. Winds were above average strength, the prevailing direction being south-westerly.

A fall of small hail during a severe thunderstorm was reported from Badulla on the afternoon of the 14th.

D. T. E. DASSANAYAKE,
Acting Superintendent, Observatory.

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EDITORIAL

THE RICE CROPS OF BURMA AND CEYLON—A COMPARISON

VERY vague ideas prevail in Ceylon regarding the methods and economics of rice growing in other countries, particularly those that find a place in the international trade in the commodity. Burma holds a predominant position in this trade, contributing about 45 per cent. of the total trade of 7½ million tons ; Siam and Indo-China contribute about 45 per cent. while all the other rice-growing countries of the world including India share the remaining 10 per cent. between them. It is too often the fashion of the people of this country to glean a few facts about the sub-tropical or non-tropical countries that represent a part of the residuary 10 per cent. and to base on them homilies on the inefficiency of our own industry without any reference to the special conditions that govern production in those countries. The most important of these conditions is a growing and maturing season of long sunny days which ensures a heavy grain crop of superior quality. The superior quality gives this rice a virtual monopoly in what may be termed the luxury market of the western countries, at prices which the oriental worker cannot pay ; and the high price reacts very favourably on production because the standard of cultivation and manuring can be pushed far beyond the margin at which the industry which produces for the cheaper market begins to become unprofitable.

The conditions of Burma are more comparable to our own, although even that country has the advantage of greater distance from the equator, and a study of Burmese rice cultivation will provide a truer basis of comparative criticism of our own. The monograph on the rice crop in Burma by Mr. J. W. Grant, M.A., B.Sc., I.A.S., Rice Expert of Burma, published as Agricultural Survey No. 17 of the Department of Agriculture of that country, supplies invaluable material for this study to a people who do not themselves cultivate the habit of travel nor encourage their Agricultural Officers to undertake general educative travel.

The outstanding feature about the Burma crop is the size of the average holding which is between 20 and 25 acres. We reproduce in page 309 of this number the paragraph which deals with costs of cultivation of this average holding, and wish

to draw special attention to the out-turn of crop, stated to be 30 baskets per acre—a basket being 46 lb.—which is the equivalent of 30 bushels of paddy. If those areas which are generally reckoned as paddy lands but should not have been brought under paddy cultivation owing to the inadequacy and uncertainty of the water supply or the unsuitability of the soil are excluded, our average annual out-turn is not less than this figure. The two agricultural practices which are common in that country but are rare in Ceylon—transplanting and the use of the wooden harrow—do not seem to give Burma an advantage over us in respect of yields. The reasons for her superior position have to be found in the longer time available for the preparatory cultivation of the soil, the efficiency of labour, and the larger size of the holding. In the absence of assured and uninterrupted artificial irrigation, the first of these factors is governed by the weather which cannot be modified by human effort. With the rains setting in in May, the rainy season is long enough to enable a paddy crop to mature when the seedlings are transplanted in the second half of August and, sometimes, even as late as the end of October. In the more important rice-growing districts of Ceylon, with rains setting in about the end of October or the first half of November, the season is too short for a crop unless the paddy is sown in the field in about the third week of November.

With regard to labour the Burmese seem to be immeasurably superior to the Ceylonese. One single process may be quoted to illustrate this difference. It is stated that in Burma 6 women will transplant one acre in a day. In those parts of the Kandy District in which the women have had training in this work, 35 women are required to transplant one acre in a day, and in those districts in which they are less skilled 40 are required. It appears to be this difference in human efficiency that enables a Burmese tenant to work a paddy farm of 25 acres, and the difference is so pronounced that its cause merits special study with a view to the improvement of our own standard.

The size of the holding constitutes the factor of predominant importance. The majority of holdings in Ceylon cannot produce the full requirements of the farmer's family between one harvest and the next, and their size cannot be enlarged so as to provide a saleable surplus unless new areas are opened up and a part of the population migrates to those areas.

From these considerations it follows that, even with prices stabilized at a reasonably high level by the operation of the Agricultural Products (Regulation) Ordinance, there are two major problems connected with the rice-growing industry which must be solved to make Ceylon even partially self-supporting —an increase in the size of the average paddy farm, and the improvement of the efficiency of labour.

RECENT PROGRESS IN THE CULTIVATION OF CAJANUS CAJAN AND THE METHODS OF PREPARING MARKETABLE DHAL IN CEYLON

P. M. GAYWALA, M.Ag. (Bombay),
DEMONSTRATOR IN CULTIVATION, FARM SCHOOL, PERADENIYA, CEYLON

IN the first article on this subject which was contributed to *The Tropical Agriculturist* April, 1938, the author described in a general manner the culture and curing of dhal chiefly based on the practices followed in different parts of India. Possibilities of the introduction of (1) this crop in the rotational scheme of village agriculture in the Dry Zone of Ceylon and (2) a new village industry of dhal-curing were also indicated. In the present paper it is proposed to deal with the progress made in the early attempts to introduce the cultivation of this crop at the Experiment Stations in the Dry Zone of Ceylon and at the same time to discuss the experience gained in the successful solution of the local problems associated with the curing of the seed so as to produce a marketable dhal of high quality.

SUITABLE VARIETIES

Before the present experiments commenced, a crop of a small-seeded, local perennial variety of dhal was being grown at the Experiment Station, Anuradhapura, for some time chiefly with the object of improving the fertility of the soil. This perennial variety, though good enough to satisfy the primary object of improving the soil fertility, was not found to behave so satisfactorily in respect of its productivity of seed. The statement below summarizes some of the draw-backs observed in the economic cultivation of this perennial variety :—

(1) The figures of yield actually obtained during the course of its three years' trial clearly indicate that it is a very poor yielder. Its cultivation is not likely to prove an economic proposition from the actual yield point of view.

(2) Harvesting of the crop is a very costly affair. With a perennial variety, the only possible method of harvesting pods at any stage is by hand-picking. The experience gained till now indicates that hand-picking which is very costly makes the cultivation of this perennial variety an unremunerative business.

(3) The seed produced is of a very small size which, on curing, yields small-sized commercial dhal and as such would not realize the normal market value.

(4) As the perennial variety is bearing pods almost throughout the year, the quality of seed is relatively more liable to be damaged by rain.

(5) Being a perennial variety and thus occupying the land for quite a long time, it could not be conveniently fitted into a balanced scheme of rotational cropping.

It would, therefore, appear that, under our dry zone conditions, the most suitable varieties should necessarily be of annual type, particularly those that mature comparatively quickly and are heavy yielders of fairly large-sized seed. Gujarat, Western India, produces the finest quality of commercial dhal from an annual variety of creamy-white, medium-sized seed. The author procured from Mr. Manilal Damodardas Shah, Jambusar, Gujarat, a free sample of about three pounds of seed of this variety and it was sown at the Experiment Stations at Peradeniya and Anuradhapura in the *yala* season of 1938. The crop commenced to flower after about 2½ months of sowing. The yield of seed from the first flowering was distinctly better than the one obtained from the perennial variety.

This small scale trial proved quite promising and, as a result, large scale trials were planned in the next season, *i.e.*, *maha* of 1938–39. A further supply of seed of the Gujarat variety was obtained from the Gujarat Seed Stores, Nadiad, Gujarat. It was decided at this stage to have some more varieties included in the comparative varietal trial. Seeds of two varieties, *viz.*, Pusa–69 and Rahar–15 were obtained from the Botanical Sub-Station, Pusa, India, for trial along with the Gujarat variety. Anuradhapura, Kotukachchiya, Tabbowa, Murunkan, and Minneriya were the centres where the trials with these three Indian varieties were carried out in the *maha* season of 1938–39.

PROPER TIME OF CULTIVATION

Normally, the dhal crop in India is sown at the commencement of the south-west monsoon (which is generally the chief monsoon in India) early in July. The seed-crop from the first flowering in this case is harvested in November or December by hand-picking of mature pods. An average woman labourer in India easily picks 50 lb. of mature pods in a working day.

Incidentally it may be of interest to note some of the profitable secondary uses of this crop. Wherever market demand (particularly in the vicinity of towns) exists, a substantial portion of the first crop is sold in the form of green pods for use as a vegetable. This practice helps the village farmer in realizing

relatively more profit. The immature seed from these green pods is as good a vegetable as the green garden peas. The use of this crop as a vegetable has been appreciated in countries outside India wherever this crop has been introduced. Once introduced and its real merits realized, it is bound to be a popular vegetable in Ceylon as well.

Soon after the harvest of the first crop of pods, second flowering commences and this yields the final crop of pods in March. The plants at this time are cut close to the land, allowed to dry and threshed. There is a great saving in the cost of harvesting of the second crop by this method.

In the dry zone of Ceylon, the north-east monsoon which commences early in October is the main season. Therefore, the proper time of sowing for this crop in the dry zone areas of Ceylon would be early in October. The first crop of mature pods would be available for picking by February or March which is a comparatively dry period. Second flowering would generally commence early in June and the crop in this case may be finally harvested in August. By adopting such a course of cultivation for this crop, it is quite possible to utilize for productive purposes the *yala* season which in many parts of the dry zone remains un-cropped at present on account of scarcity of water sufficient to start a new crop.

REVIEW OF THE EXPERIENCE IN THE CULTIVATION OF DHAL CROP AT THE DRY ZONE STATIONS IN THE MAHA SEASON OF 1938–39.

Anuradhapura.—At this station each of three varieties was planted on an acre of land. The sowing was done on January 10 to 15, 1939, by dibbling with a spacing of 3′×3′.

The Gujarat variety flowered in the last week of March, but the flowers wilted and dropped on account of prolonged drought. With the subsequent rains in April, new flowers began to appear. However, again the crop received a serious set-back during the period of severe drought in May. Again with rain, a vigorous flowering commenced in June, 1939. This flowering resulted in successful fruiting and it was possible to harvest till August 9, 1939, 582 lb. seed of good quality from an acre of land. This can be taken as a very satisfactory yield only from one flowering particularly on such a light and gravelly type of soil under abnormal climatic conditions. Compared with the other two Pusa varieties, the growth of Gujarat variety has been much more vigorous with extensive side branching.

The two Pusa varieties have been found to be very late-maturing under our conditions. They commenced to flower late in June and, by the middle of August, the flowering had not substantially progressed or resulted in pods.

The crop of all three varieties has been remarkably free from the attack of wilt. The only damaging insect-pests that were observed were (1) pod-borer which belongs to *agromyza* species and (2) blister beetles. The attack of pod-borer has not been serious on this station and its incidence throughout the growing period of the Gujarat variety was below 5 per cent. Blister beetles appear with the commencement of flowering and continue throughout the subsequent growing period. It eats flowers, tender leaves and pods. These beetles were collected by hand and destroyed. The incidence of damage by this pest ranged from 5 to 10 per cent.

Had the Gujarat variety been sown early in October, 1938, it would have been ready for the first picking of pods in March, 1939. In that case it would have been possible to harvest the first crop in the much desired dry period of March and it would not have suffered, as it did in the present case during its flowering period, on account of drought.

Kotukachchiya.—At this place dhal is cultivated as an inter-crop in the un-occupied space between the young cashew nut trees which are planted 20 feet apart on either side. The sowing of the whole crop was done very late, *viz.*, in November and December, 1938, as more attention was devoted to cashew nut during the earlier part of the season. The spacing of the crop with all the three varieties was $3' \times 2'$. The land was recently cleared and has not been stumped. It is not protected by the usual soil conservation measures. The whole area of about 51 acres had to be sown by dibbling. The Gujarat variety occupied 31 acres and each of the two Pusa varieties was grown on 10 acres. In spite of poor rainfall, the crop in its early stages appeared quite satisfactory.

The Gujarat variety flowered early in February and the picking of pods commenced in the last week of March. However, unusual rain of a fairly heavy character which commenced from March 29 (when the pods were in a stage of formation and active development), and continued till May 10, brought about practically a complete failure of the crop from the first flowering. To add to the trouble, the bund of a tank close to the farm burst and about half the area under this variety was flooded. The incidence of the attack of pod-borer during the days of continuous rain was very high. Second flowering started early in June and a crop of mature pods was harvested in August. Here also the late sowing had been greatly responsible for the loss of crop from the first flowering. Had the crop been planted early in October, mature pods from the first flowering would have normally been harvested by the end of March before the continuous rain started.

The two Pusa varieties have been found to be very late-maturing here as well. They commenced to flower from the first week of August.

The experience with regard to the relative growth of the three varieties of dhal at Tabbowa, Murunkan and Minneriya is of an identical character.

The experience at all the stations clearly indicates that under our dry zone conditions, both the Pusa varieties have proved very late-maturing. They have therefore to be discontinued from the present trials with effect from the next season. However, on account of their thick vegetative growth, there is a possibility of their being suitable for fodder purposes in Jaffna District where, at present, mostly the perennial variety of dhal is grown on a small scale. The leafy fodder of this crop appears to be as good as lucerne. The Pusa varieties may therefore be tried for fodder purposes in Jaffna District.

The Gujarat variety seems to be quite promising and its continuation along with a few more new quick-maturing varieties will form the basis of trial for the next season.

The cultural trials of dhal varieties may also be introduced with advantage in other parts of the dry zone such as the neighbourhood of Hambantota, Batticaloa and Trincomalee in the next season so that we might be able to judge the extent to which these parts of the dry zone will be suitable for the extension of dhal cultivation in future.

SUGGESTED CULTURAL PRACTICES FOR DRY ZONE STATIONS IN THE LIGHT OF RECENT EXPERIENCE

Keeping in view the local experience gained in the last season, the following suggestions are made for the cultivation of dhal as an entire crop (not a mixed crop) in the dry zone stations.

SOWING TIME

The most suitable time to sow this crop in the dry zone appears to be early October, the period of commencement of the north-east monsoon.

METHOD OF SOWING

The spacing should be $3' \times 2'$ with all the varieties. The seeds (3 to 4 per hill) will have to be dibbled to this spacing as we have not the appropriate kind of seed-drill and as sometimes the crop is to be planted on land from which stumps are not removed, *e.g.*, at Kotukachchiya.

CULTURAL METHOD

In the case of a land under regular cultivation, it is necessary that the land should be prepared for sowing in the usual manner by ploughing and harrowing. In the case of a newly-cleared

land where stumps have not been removed, the soil is expected to be in a better physical state and, therefore, preparatory cultivation may be dispensed with and only slight digging for making holes for dibbling would serve the purpose. After the germination is complete, filling of gaps and thinning wherever necessary allowing only two plants to remain in each hill, may be taken up as soon as possible. Only one weeding will normally be sufficient and the appropriate time for it will be any time after four weeks and before nine weeks of sowing. Second weeding may become necessary under certain conditions. The weeding times will have to be adjusted according to the season and the degree of weed growth under specific local conditions.

The first crop of pods is usually ready by February or March and will have to be harvested by hand-picking. The possibilities of utilization of green, tender pods as a vegetable might be explored. After the harvest of the first crop, second flowering would normally commence early in June. When most of the pods in the second flowering have reached maturity, the crop may be finally removed in August by cutting the plants close to the land.

TYPES OF COMMERCIAL DHAL AVAILABLE IN CEYLON MARKETS

At least five different kinds of products are available under the common name of dhal in the Colombo market. As there is a lot of misunderstanding about these different types of dhal, it would be useful, before we proceed further, to describe each of them so as to distinguish the one from the other.

The first is the oiled dhal which comes from Bombay. It is prepared entirely by the dry method (Refer pages 218 to 220 of *The Tropical Agriculturist*, April, 1938) from the seed of *Cajanus cajan* alone. A liberal amount of gingelly oil is used during the course of its curing and at the end of the curing process. It has all the desirable qualities of the best dhal, *viz.*, attractive appearance, absence of depression in the centre, golden yellow colour, ability to be quickly cooked to a softness and the best flavour. It sells in the Colombo market at about Rs. 6·25 per bushel. Unfortunately this dhal, being very costly, has not been able to find extensive local use and its merits have remained almost un-appreciated.

The second type of dhal is also made from *Cajanus cajan*. It is prepared either by the combined dry and wet method (which will be described at a later stage) or only by the dry method with very limited use of oil. It is of quite a good quality. Though not very oily in appearance, it looks attractive. It is free from depression in the centre but it takes a little more time to cook to a softness. It sells in the Colombo market at about Rs. 5·25

per bushel. This type of dhal, though not used in very large quantity, is certainly used to a much greater extent than the first one.

The third is the dhal from *Cajanus cajan* prepared by the wet method and it has its origin in South India. It is in fairly extensive use all over Ceylon. It has a well-marked depression in the centre ; takes a fairly long time to cook and even then does not get reduced to a homogeneous semi-liquid mass ; is not as attractive in appearance as the two varieties described in the foregoing paragraphs and, on cooking, does not have the characteristic flavour associated with those two types. It sells at about Rs. 4 to Rs. 4·25 per bushel in the Colombo market. Being cheap, it is used extensively and finds a ready sale.

The fourth type of dhal is a large-sized one without any depression in the centre, fairly attractive in appearance and is not treated with oil. This dhal cooks to a softness comparatively quickly but lacks badly in flavour. It sells in the Colombo market at about Rs. 3·50 per bushel. This dhal is not strictly prepared from the seed of *Cajanus cajan* but is a mixture of dhal from *Cajanus cajan*, field peas (*Pisum arvense*) and some other pulses. The percentage proportion of field peas is very high in this dhal. The seed of field peas realizes in the Indian market only 66 to 75 per cent. of the price realized by the seed of *Cajanus cajan*. Naturally, therefore, any commercial dhal which contains a high proportion of field peas is bound to be cheaper. This dhal is also in fairly extensive use. It is shipped to Colombo from Calcutta.

The fifth and the last type of dhal is entirely a different type and it has no relation or similarity to the dhal from *Cajanus cajan*. It is pinkish-red in colour, much smaller in size and cooks very quickly. It is wrongly known locally as *Mysore dhal*. In India it is known as *Masur dhal* and is chiefly cured from the seed of the common lentil (*Lens esculenta*) which is a small herb and is entirely different from *Cajanus cajan*. The pinkish-red colour of this dhal is its natural colour. This sells at about Rs. 4 per bushel and is extensively used all over Ceylon.

The object of the present experiments has been to produce a good type of marketable dhal from *Cajanus cajan* and our attention for the present will, therefore, be chiefly devoted to the problems of curing of dhal from *Cajanus cajan* alone.

SUITABLE METHODS OF CURING UNDER LOCAL CONDITIONS

There are two principal methods of curing dhal followed in different parts of India. Both of these methods have already been described in the author's first article. The advantages, disadvantages and the adaptability under local conditions of

each of these two methods were studied during the course of the preliminary curing trials. As a result of this study, it was realized that the wet method followed in South India is practically of no use under Ceylon conditions in spite of the advantage of slight cheapness in its favour.

The irregularity of weather conditions which is a common feature almost everywhere in this country, has a comparatively more deleterious effect on the wet method than on the dry method. For example, during the course of curing by the wet method, continuous rain or cloudy weather may occur for 4 or 5 days at a stage when the seed has been kept for drying after soaking it in water. The seed would not dry to the required extent under such conditions and would undergo unduly prolonged fermentation. This over-fermentation creates an undesirable odour in the final product and the quality of the whole lot is spoiled. This difficulty had actually been experienced during the course of the trial of the wet method on a former occasion at Anuradhapura. This method is, therefore, attended by the risk of damage or even absolute loss of all the seed in the event of any irregularity in the weather. The dry method, from this point of view, is quite safe. If there is rain at any stage of curing by this method, the seed can be stored indoors indefinitely without any detrimental effect. Besides this distinct advantage of safety, the dhal obtained by the dry method is quite free from the depression in the centre, has an attractive appearance, is superior in cooking quality and flavour and is capable of being stored without damage for a relatively longer period.

PROBLEMS ASSOCIATED WITH THE DRY METHOD OF CURING AND THE RESULTING MODIFICATIONS IN THE PROCESS TO SUIT LOCAL REQUIREMENTS

During the early trials of curing, it was realized that even the dry method of curing could not be adopted entirely in the form in which it is followed in India and that it required some important modifications to suit our local requirements.

The oil in general use in India for this purpose is gingelly oil because it appeals to the taste of the people and it is available in good quality at a reasonably low price in the Indian villages. The position in Ceylon is quite different in this respect. People in Ceylon generally like coconut oil better and it is available in the villages at a reasonably low price. Attempts were, therefore, made in the later trials to use coconut oil instead of gingelly oil. This has succeeded remarkably well with the modification in the technique of the dry method. In the modified dry method, the quantity of oil to be used during the curing process is greatly reduced and the application of oil at the end

of curing is entirely dispensed with. It is for this reason that the cured dhal does not continue to retain the characteristic flavour of coconut oil and therefore the possibility of the dhal cured with coconut oil acquiring rancidity during the storage period is entirely eliminated.

The second problem to be solved was to avoid as far as possible the oily appearance of the cured dhal as the people in Ceylon have not acquired the taste for the oily-looking dhal. With the modification in the method of dry curing, it has now been possible to reduce this oily appearance of cured dhal to a minimum, and it can be further reduced if necessary to a marked extent by the adoption of the combined dry and the wet methods of curing.

The next problem was to eliminate the minimum resting period of a fortnight which is necessary at an intermediate stage in the case of the formerly-described dry method. This step was desirable in view of the fact that the dhal-curing season available in Ceylon is of a shorter duration than in India. The observation of a fortnight's resting period would have the effect of further shortening the already short period of the curing season. This resting period is eliminated in the modified dry method of curing. The number of splittings have been increased from two to four to counteract the effect of elimination of the resting period.

This modified dry method has been found admirably to suit the local conditions and it yields a dhal of fine quality with the least possible oily appearance.

DESCRIPTION OF THE MODIFIED DRY METHOD OF CURING ADAPTED FOR LOCAL CONDITIONS

Before the actual curing process commences, it is desirable to grade the seed by means of appropriate sieves into three lots according to size. The three grades are: large, medium and small. This preliminary grading facilitates the splitting. If grading is not done, the splitting in the mill will not be of an even character on account of the variation in the size of seed, and there is a possibility of relatively more breakage of the dhal. From an average good crop, the percentage proportion of the three grades of seed is: first grade 80 per cent., second grade 17 per cent. and third grade 3 per cent. The curing of the first and the second grade seed is done in separate lots and the cured dhal may be marketed in separate grades or may be mixed together and marketed in the mixed form. The third grade seed which is very small-sized and imperfectly developed is not utilized for the curing as the resulting dhal is not likely to find a ready sale at a reasonable price. In India it is merely split and sold as a cattle food. In this form it realizes in the

Indian market a price of about two cents per pound. In this way the third grade seed which is otherwise useless for curing of dhal, is economically disposed of.

This process of curing can be conveniently divided into the following six stages :—

(1) *First splitting.*—Preliminary sun-drying before splitting is necessary only if the seed has not been sufficiently dried after threshing. The first splitting in the stone mill is very light and as a result only about 6 per cent. of the seed is split. The clearance between the two stones of the mill at the time of this splitting is the maximum and the seed is rapidly fed in large quantity at a time. The object of this light splitting is only to crack the seed coats. The partially-split seed with cracked seed coat is known as *dol.*

(2) *First application of oil and drying under sun.*—After the first splitting, the broken part of the dhal called *chuni* is separated with the help of a round sieve with small mesh (Fig. 1) If a fair amount of seed coats are separated they may be winnowed out, otherwise this is not necessary. The *dol* is then treated with coconut oil (Fig. 2) at the rate of one pound per 128 lb. *dol* in the morning and immediately exposed to the sun (Fig. 3) for drying. The duration of the drying period ranges from 1 to 3 days depending upon the intensity of heat of the sun and the thickness of the layer of *dol.* If the sun is mild or if the *dol* is spread in a thick layer, sun-drying for a longer period is necessary. While drying, it is essential frequently to disturb the *dol* so that the drying may be even.

(3) *Second splitting.*—After it is fully dry, the second splitting of *dol* commences. This splitting is also light and a further 13 per cent. of the seed gets split. This second splitting can be done in the evening after the *dol* has been dried during the day. The split material is then passed through a round, small-meshed sieve to separate the *chuni.* The seed coats may also be removed if necessary by winnowing.

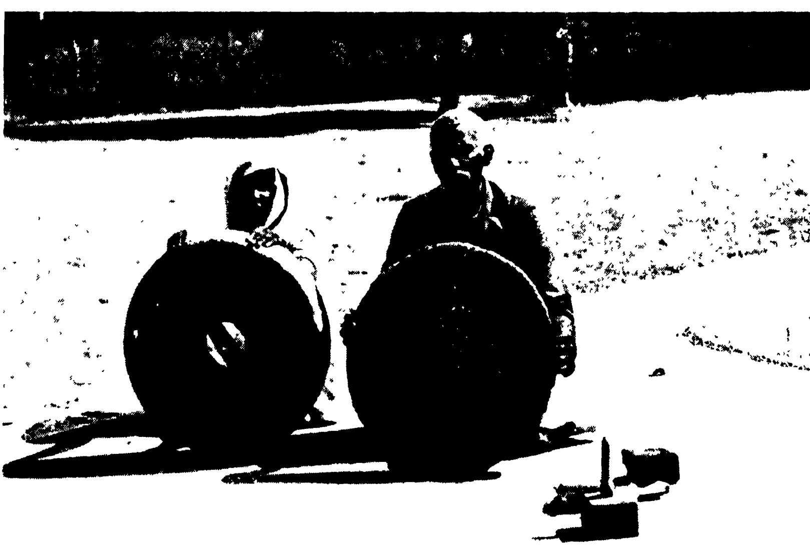
(4) *Second application of oil and drying under sun.*—The *dol* at this stage is treated with coconut oil at the rate of one pound per 225 lb. *dol* in the morning and spread for drying under the sun for a day or two depending on the intensity of heat and the thickness of the layer of dol.

(5) *Third splitting.*—(The *dol* is now ready for the third splitting. This third splitting should be of a fairly heavy character. This is possible by slightly reducing the clearance between the two stones of the mill. A further 38 per cent. of the seed gets split at this time. After the splitting is over, the *chuni* and the seed coats are as usual separated from the

FIG. 1.—SIEVES AT WORK DURING THE PROCESS OF DHAL-CURING.

FIG. 2.—THE *Dol* BEING TREATED WITH COCONUT OIL.

FIG. 3.—THE OIL-TREATED *Dol* BEING SPREAD FOR DRYING IN THE SUN.



Block by Survey Dept. Ceylon.

FIG. 4.—WOODEN PARTS AND SIDE VIEW OF THE VILLAGE MODEL OF DHAL-SPLITTING MILL.

dol. The slightly broken dhal pieces may, if necessary, be separated by the appropriately meshed round sieve. Dhal is not to be separated from *dol* even at the end of the third splitting. No oil is to be applied at the end of the third splitting.

(6) *Sun-drying and fourth splitting.*—The material is kept for drying this time only for a day. It is then finally split for the fourth time. This splitting is also fairly heavy. Most of the *dol* is split at this time. The split material is passed through the rectangular steel sieve which separates the dhal. The *chuni*, broken dhal, and seed coats are separated in the usual manner described before. If the separated dhal has some proportion of seed coats still adhering, the seed coats can be separated from the dhal by lightly pounding it with the wooden mortar and pestle. About 3 per cent. of the *dol* remains unsplit even at the end of the fourth splitting. This can be finally split by immediately feeding it again in the mill without drying under sun or application of oil.

By this process dhal can be cured within a period of 7 to 8 days. The cured dhal does not look very oily and has all the desirable characteristics of good quality dhal. From the good seed of the first and second grade, the approximate percentage proportion of different dhal products as a result of satisfactory curing should be: 66 to 70 per cent. of good dhal saleable at full market value, 5 to 9 per cent. broken dhal saleable at about half the price of good dhal, 13 per cent. *chuni* or powdered dhal saleable in the Indian market at about 2½ cents per pound, and 12 per cent. seed coats saleable in the Indian market at about 1½ cents per pound. It may be of interest to note here that the results of the local curing trials from good seed have favourably compared with these Indian averages.

DESCRIPTION OF THE COMBINED DRY AND WET METHOD OF CURING DHAL ADAPTED FOR LOCAL CONDITIONS

Here also the seed requires to be graded as in the case of the dry method. The principal difference in this method is the use of a mixture of oil and water instead of oil alone. This process of curing can be conveniently divided into the following five stages:—

(1) *First splitting.*—The first splitting in the stone mill is fairly light and as a result about 20 per cent. of the seed is split. The *chuni* is separated out from the *dol*.

(2) *Application of a mixture of oil and water and drying under sun.*—The *dol* is treated with a mixture of oil and water in the evening. For 128 lb. seed, one pound of oil and five pounds of water are necessary. Coconut oil has been found to serve the purpose quite satisfactorily. The oil and water are first mixed in a bucket and gradually incorporated into the *dol*. When thoroughly mixed, it is heaped up and kept in that condition

for the whole night. The heap is disturbed in the morning and the material exposed in a thin layer to dry in the sun. The *dol* is allowed to dry for 3 to 4 days according to the intensity of heat of the sun.

(3) *Second splitting.*—When thoroughly dry, it is split for the second time fairly heavily, *i.e.*, with less clearance between the two stones of the mill. At this time a further 50 to 60 per cent. of the seed gets split. The dhal, broken dhal, *chuni* and the seed coats are separated from the unsplit *dol*. The dhal is finally cleaned and kept separately.

(4) *Second application of a mixture of oil and water and drying under sun.*—The unsplit *dol* is again treated with a mixture of oil and water in the same proportion and heaped up for the night. From the next morning for 3 to 4 days it is exposed to the sun for drying.

(5) *Third splitting.*—When thoroughly dry, the *dol* is split for the third time. Dhal is separated from the other by-products in the manner already described.

If the separated dhal has some proportion of seed coats still adhering, the seed coats can be separated by lightly pounding the dhal with the help of a wooden mortar and a pestle which are commonly seen in the villages.

Curing by this method yields almost the same proportion of dhal and other by-products. The dhal cured by this method looks less oily but is slightly difficult to cook.

STONE MILLS USED IN SPLITTING DHAL AND OTHER EQUIPMENT NECESSARY FOR DHAL CURING

The success of dhal-curing depends to a great extent upon the use of a right kind of splitting mill. Sometimes the distinction between the splitting and the grinding mill is not properly understood. Splitting mills are provided with devices for adjusting the clearance space between the lower and the upper stones enabling the degree of splitting of seed to be regulated. This makes the mill also adaptable for splitting a wide range of pulse seeds which appreciably vary in size. In the grinding mill, such a facility does not exist and, therefore, any material fed into such a mill is reduced to powder.

In Gujarat, Western India, two models of splitting mills are in general use. Both models were brought by the author from Gujarat and used during the course of the curing trials described in this paper. The one known as the village model is a relatively small-sized, handy, flat-shaped mill with an approximate weight of 150 lb. It costs about Rs. 15. It requires to be worked by two persons and it can split about 600 to 900 lb. of seed in a working day of 8 hours depending on the skill of the workers. Figs. 4, 5 and 6 illustrate the different parts, side view,

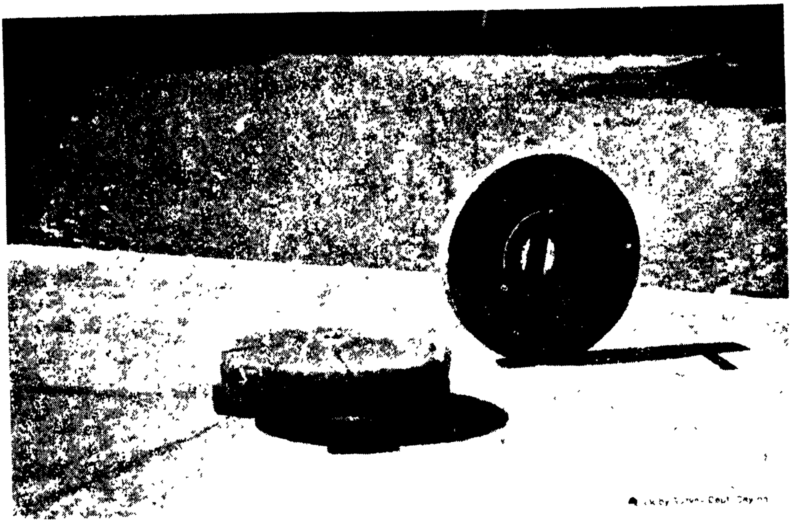


FIG. 5.- WOODEN PARTS AND SIDE VIEW OF THE VILLAGE MODEL OF DHAL-SPLITTING MILL.

FIG. 6.- DHAL-SPLITTING MILL . VILLAGE MODEL.

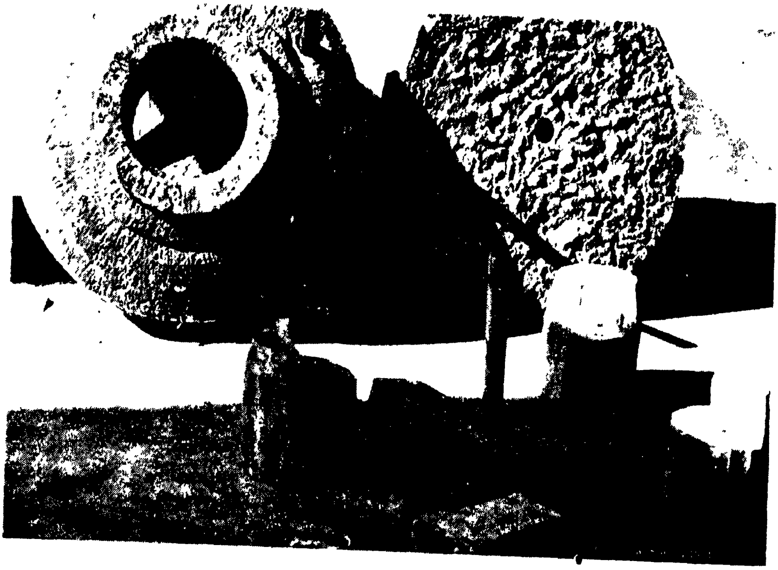


FIG. 7.- WOODEN PARTS AND SIDE VIEW OF THE COMMERCIAL MODEL OF DHAL-SPLITTING MILL.

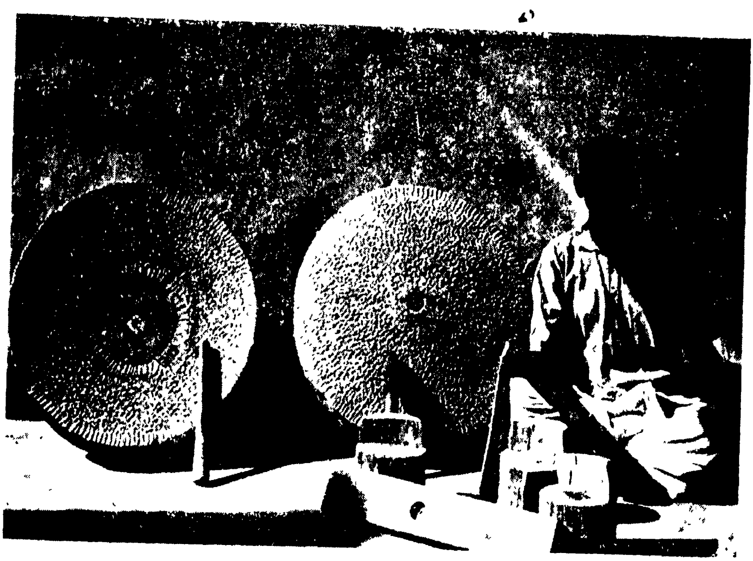


FIG. 8.- WOODEN PARTS AND SIDE VIEW OF THE COMMERCIAL MODEL OF DHAL SPLITTING MILL.

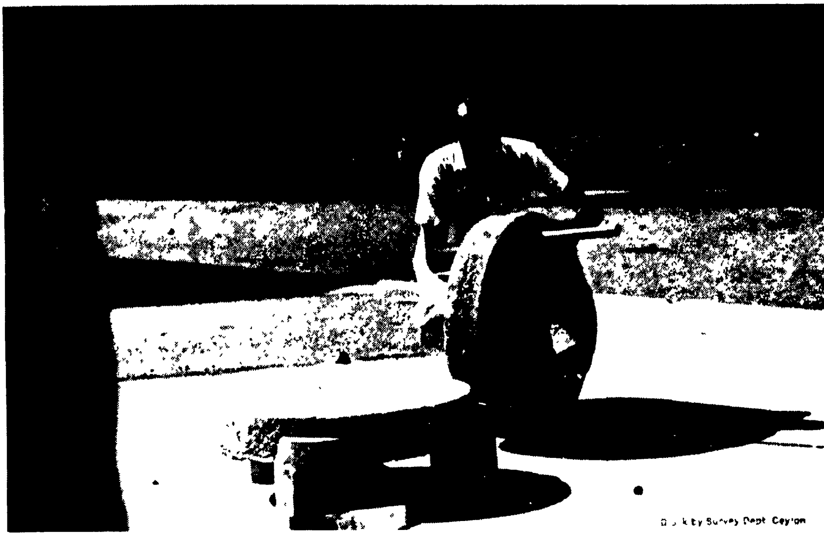


FIG. 9.- SIDE VIEW OF THE COMMERCIAL MODEL OF DHAL-SPLITTING MILL.

FIG. 10. DHAL-SPLITTING MILL, COMMERCIAL MODEL

the actual working of this model and the relative position of the workers while working. This type of mill is generally used by the villagers who have to cure dhal on a small scale to meet the requirements of the village.

The other is the commercial model which is dome-shaped and quite heavy. This mill weighs about 500 lb. and its cost is Rs. 25. This is generally used in the towns by the professional dhal-curers known as *golas* who cure fairly large quantities of dhal. This model is also worked by two persons at a time and, though apparently very heavy looking, is quite light in actual working on account of the ease with which it is possible to adjust the clearance between the lower and the upper stones. It can split about 1,200 to 1,600 lb. of seed in a working day of 8 hours, depending on the experience of the operators. Figs. 7 to 11 illustrate the different parts and side views of the mill, the mill ready for work and in actual working showing the relative position of the operators.

Besides the splitting mills, sieves of different kinds and winnowing fan are required to separate the by-products from dhal at various stages of the curing. These are illustrated in Fig. 12. The round sieves are used according to the size of the mesh for grading seed, for separating powdered dhal and broken pieces of dhal. The rectangular steel sieves separate the dhal from the unsplit *dol.* The winnowing fan is used in separating the seed coats from *dol,* dhal and dhal pieces.

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The author desires to take this opportunity to express his grateful acknowledgments to Mr. C. N. E. J. de Mel, Principal, Farm School, Peradeniya, for all the necessary facilities offered during the progress of this work. His thanks are also due to Mr. E. S. Jayasundera, the Manager, Experiment Station, Anuradhapura, for his willing assistance, co-operation and interest in this work at Anuradhapura, to Mr. G. Harbord, the Divisional Agricultural Officer, N.D., and Mr. S. J. F. Dias, the Divisional Agricultural Officer, N.W.D. for their co-operation in the trials carried out in their respective divisions, to Mr. T. V. Thamotheram, the Agricultural Instructor, Puttalam for the trials at Kotukachchiya and to Mr. Wirasinhe of the Propaganda Division for taking photographs of the equipment of the dhal-curing industry which appear in this paper.

FIELD-PLOT TECHNIQUE WITH CHILLIES (CAPSICUM ANNUUM L.)

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FIELD trials laid down in the past in Ceylon have suffered considerably from the lack of exact information regarding optimum sizes, shapes and arrangements of plots. Uniformity trials with rice carried out by Lord (1931) represent the only attempts hitherto made in this country at securing information of this nature for annual crops. This communication presents the results of a uniformity trial set down at the Experiment Station, Anuradhapura, during the *maha* season, 1938–39, for the purpose of investigating methods of increasing the precision of field experiments with chillies (*Capsicum annuum* L.)

MATERIAL

The field selected for the trial was just over an acre in extent, and had carried crops of cotton, kurakkan, and gingelly in previous seasons. The soil was a sandy loam overlying a heavier loam rich in quartz gravel, and was of average fertility. The land was comparatively level, and soil heterogeneity, as indicated by previous crops, was not considerable. The variety of chilli grown was Tuticorin. Nurseries were sown on September 19, 1938, and the seedlings transplanted at the rate of two per hill on November 1. The seedlings had been topped prior to transplanting, and a spacing of 3 ft.×3 ft. was adopted. Nearly fifty per cent. of the plants had set fruit by the end of December. A few plants were attacked at the collar by *Sclerotium Rolfsii* Sacc. This damage apart, there was no interference by any major disease or pest. Some time before the harvest, the area was lined out into 96 unit plots, six plants square. A nett area of 0·71 acre was harvested after the exclusion of a 21 feet border all round. The yields of unit plots represent the aggregates of nine pickings of ripe chillies, extending from January 2 to April 1, 1939. Rainfall during the experimental season was normal.

STATISTICAL ANALYSIS

1. *Percentage standard error*—

The area harvested consisted of 96 unit plots arranged in eight rows of 12 plots running north to south. Unit plots measuring 18 ft.×18 ft. were combined to form plots of various sizes and shapes. For the purpose of the analysis of variance (Fisher, 1930), four hypothetical treatments or varieties were assumed. The four plots within each block could be placed in a row running either north to south or east to west, or they may be disposed in a 2×2 arrangement. A fraction of the total variability was removed in the variance between these four-plot blocks, the magnitude of the fraction being determined by the efficiency of the size, shape and arrangement of blocks. The residual variance provided an estimate of experimental error. The standard error per plot was obtained by taking the square root of the error variance, and was expressed as a percentage of the mean. Twenty-eight combinations of unit plots were analysed. The results are recorded in Table 1.

TABLE 1.

	Plot size (acre)	Arrangement of units within plots	Arrangement of plots within blocks	Percentage standard error per plot	No. of replications needed to reduce S.E. of mean to 4 per cent.	Area of land needed to reduce S.E. of mean to 4 per cent. (acres).	Efficiency (per cent.)
I.	1/134	1×1	4×1	13·9	13	0·39	100
II.	1/134	1×1	2×2	21·4	38	1·13	33
III.	1/134	1×1	1×4	21·8	39	1·16	31
IV.	1/67	1×2	1×4	12·6	10	0·60	61
V.	1/67	1×2	4×1	10·7	8	0.48	84
VI.	1/67	1×2	2×2	11·2	8	0·48	77
VII.	1/67	2×1	1×4	24·1	36	2·15	17
VIII.	1/67	2×1	2×2	23·8	36	2·15	17
IX.	1/45	3×1	4×1	17·7	20	1·78	21
X.	1/45	3×1	2×2	24·6	38	3·38	11
XI.*	1/45	1×3	4×1	9·2	6	0·53	76
XII.*	1/45	1×3	2×2	8·8	5	0·44	83
XIII.	1/34	4×1	1×4	22·4	32	3·76	10
XIV.	1/34	1×4	4×1	8·6	5	0·59	65
XV.	1/34	1×4	2×2	10·8	8	0·94	41
XVI.	1/34	2×2	1×4	11·7	9	1·06	35
XVII.	1/34	2×2	2×2	9·7	6	0·71	51
XVIII.	1/22	6×1	2×2	22·1	31	5·64	7
XIX.	1/22	6×1	1×4	21·1	28	5·09	7
XX.	1/22	3×2	2×2	12·5	10	1·82	21
XXI.	1/22	3×2	4×1	14·3	13	2·36	16
XXII.	1/22	3×2	1×4	10·7	8	1·45	28
XXIII.*	1/22	2×3	2×2	8·0	4	0·73	50
XXIV.*	1/22	1×6	4×1	7·2	4	0·73	62
XXV.	1/17	1×8	4×1	7·7	4	0·94	41
XXVI.	1/17	2×4	2×2	9·5	6	1·41	27
XXVII.	1/17	4×2	1×4	10·2	8	1·88	23
XXVIII.	1/11	12×1	1×4	19·1	23	8·36	4

In the instance of four combinations (marked with asterisks in this Table) it was found necessary to exclude two rows of 12 plots each. The second column in this table gives the arrangement of units within plots, the first figure in each instance indicating the dimensions in the north-south direction, and the second figure the dimensions in the east-west direction. Combination number xxii, for instance, consisted of six units and was three units long in the north-south direction, and two units broad. The disposition of plots within blocks is indicated

in a similar manner in the third column. Each block in combination number xxii consisted, for example, of a single row of four plots running east to west.

The percentage standard errors per plot for the various combinations are recorded in the fourth column of Table 1., and a fertility contour map of the experimental area is presented in Fig. 1. A feature of this field was its marked fertility gradient in the east-west direction, the soil heterogeneity being distributed in long, narrow strips extending north to south. It is evident that the between-plot variability can be reduced to a minimum by the use of long, narrow plots oriented in a direction that will permit their intersecting a maximum number of fertility contour lines. Reference to Table 1 shows that plots elongated in the east-west direction do, in fact, yield the lowest errors. Plots elongated in the north-south direction are even more unsatisfactory than square plots. A striking illustration of this fact is seen in combinations xiii and xiv; by changing the direction of plot elongation, the standard error is reduced from 22·4 per cent. to 8·6 per cent.

The standard errors of well oriented and badly oriented plots have been extracted from Table 1, averaged and tabulated in Table 2 according to plot size. Square plots constitute a class intermediate in efficiency.

TABLE 2.

Plot Size (Acre)	Average Percentage Standard Errors per Plot. Well Oriented Plots.	Square Plots.	Badly Oriented Plots.
1/134	—	21·0	—
1/67	11·5	—	24·0
1/45	9·0	—	21·2
1/34	9·7	10·7	22·4
1/22	7·6	—	16·1
1/17	8·6	—	10·2
1/11	—	—	19·1

The average standard errors of well-oriented plots show a decrease with increase in plot size, the lowest error being obtained with 1/22 acre plots. There is, however, no considerable decline in standard error with increasing plot size after the 1/45 acre mark is passed. A plot size of 1/45 acre may accordingly be recommended for field experiments with chillies.

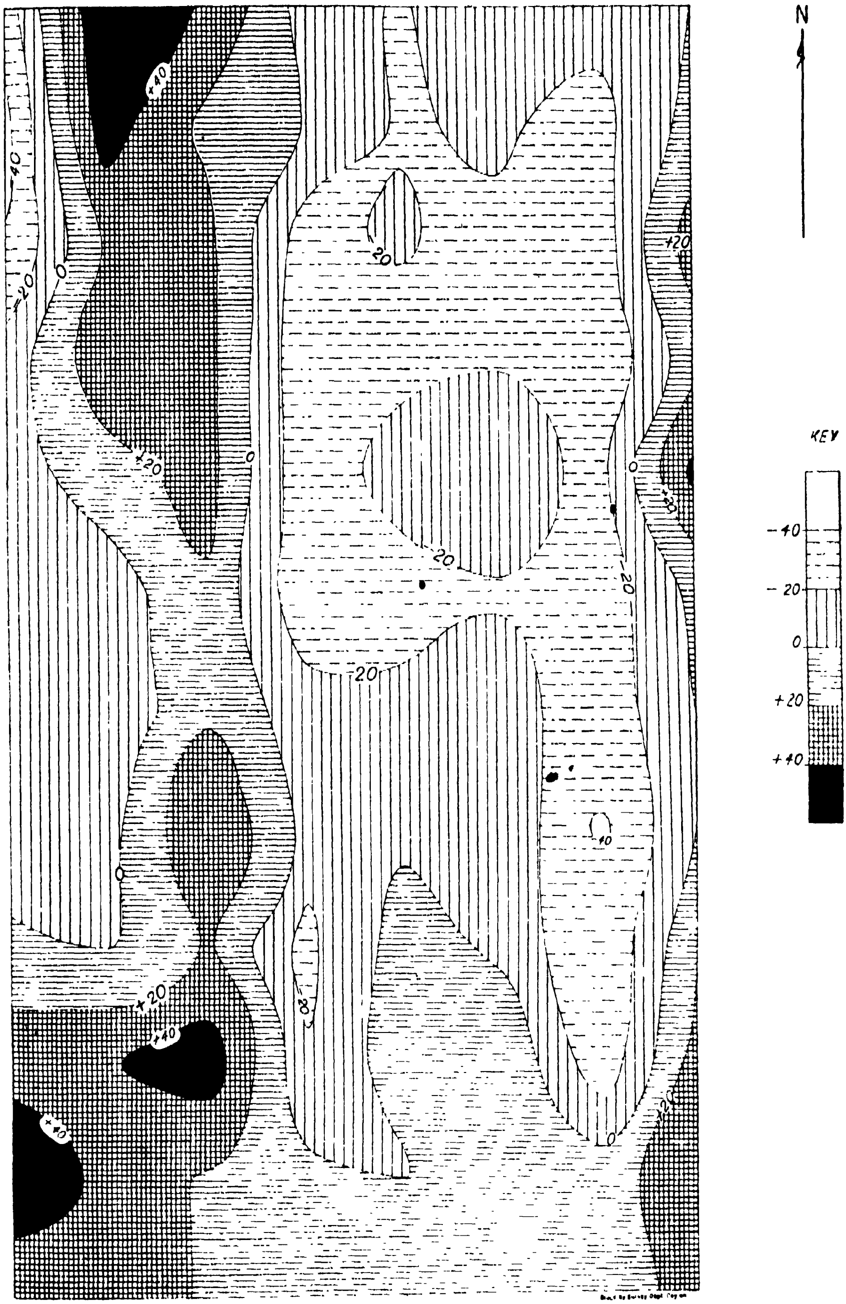

FIG. I.- FERTILITY CONTOUR MAP OF THE EXPERIMENTAL AREA (CHILLIES).

2. *Number of replications and total area of land needed*— Column six in Table 2 records the numbers of replications necessary to reduce the standard error of the mean to 4 per cent. The figures have been given to the nearest whole number, fractions of replicates being treated as wholes. Calculations are based on the fact that the standard error of the mean of N replicates is obtained by dividing the standard error of a single plot by the square root of N. The total areas of land required to effect this reduction to 4 per cent. are given in column seven of Table 1. If the usual convention of regarding differences greater than twice the standard error as significant, is assumed, this reduction will allow the demonstration of the significance of differences between means greater than 11 per cent. If the detection of more subtle differences, say, of the order of 5–6 per cent., is desired, the standard error of the mean should be reduced to 2 per cent. The numbers of replications and the areas of land then needed will be exactly 4 times the values in Table 2. In well-oriented plots, the diminution in standard error with increase in plot size, of course, manifests itself in a progressive reduction in the number of replications needed.

3. *Efficiency of plots in the use of land*—
The extent of land suitable for experiments is often extremely limited, and the most efficient exploitation of a particular piece of land often becomes a question of major importance. An estimate of the efficiency of a particular type of plot in the use of land is provided by the reciprocal of the product of the variance per plot and the number of units that constitutes the plot (Justesen, 1932 and Kalamkar, 1932). In the last column of Table 1, the efficiencies of various arrangements are expressed as percentages of the efficiency of the unit plot arrangement with the lowest standard error. Plot efficiencies are seen to decline with increase in plot size. When the land available is of limited extent, it is usually preferable to secure increased replication at the sacrifice of plot size.

DISCUSSION

In designing a field experiment, the agronomist aims at removing as much of the total variation as possible in the variances within plots and between blocks, the residual within-block variance which provides the estimate of error being reduced to minimum dimensions. Most investigators have found that these objects can be achieved by the use of long, narrow plots arranged side by side in compact blocks. It must be added, however, that the efficiency of the long, narrow plot may be conditioned to a considerable extent by its orientation. If, as in the present experiment, the field exhibits a pronounced fertility trend, it is important that the direction of plot elongation should be parallel to this gradient. Long, narrow plots that cut across the fertility gradient, yield larger errors than even square plots.

A detailed discussion of the relative merits of square and oblong plots is not attempted here. It may be pointed out, however, that considerations other than statistical ones may dictate the choice of plot shape. For instance, if cultivation and handling of the crop is done by hand, square plots may not be disadvantageous. If machinery is employed, long, narrow plots may be desirable. The relatively low perimeter of the square plot is a point in its favour, especially when marginal effects are considerable and guard rows have to be excluded.

The optimum direction of block elongation is perpendicular to the optimum direction of plot elongation. Although it is generally true that compact blocks, by the approximation of centres of constituent plots, reduce the within-block variance considerably, it sometimes happens, as in the present experiment, that long narrow plots placed end-on give a lower error than the more compact arrangements. In such instances, long blocks almost completely occupy strips of either high or low fertility and a large fraction of the soil heterogeneity then comes off in the between-block variance.

When suitable land is scarce, the proved efficiency of small plots may suggest the use of very small plots with a high degree of replication. Diminutive plots have, however, considerable disadvantages including the elaborateness of the lay-out and harvesting arrangements, and the loss of a relatively large proportion of the plot area in instances where guard rows are discarded. In Ceylon especially, where much of the experimentation has to be done with unskilled labour, designs should be rendered as fool-proof as possible.

SUMMARY

1. The results of a uniformity trial with chillies (*Capsicum annuum* L.) carried out at the Experiment Station, Anuradhapura, during the *maha* season, 1938–39, are presented.

2. The experimental field exhibited a pronounced fertility trend.

3. Long, narrow plots elongated in the direction of the fertility trend, yielded the lowest errors.

4. In well-oriented plots, the percentage standard error decreased with increase in size of plot. A plot size of 1/45 acre is recommended for field experiments with chillies.

5. Information regarding the number of replications and the area of land necessary for demonstrating differences of a certain magnitude, is provided.

6. Small plots were more efficient in the use of land than large plots.

ACKNOWLEDGEMENT

The writers gratefully acknowledge their indebtedness to Mr. E. S. Jayasundera, Anuradhapura, for the careful supervision of the field arrangements and for the collection of the data. They also thank Mr. G. Harbord, Agricultural Officer, Northern, for his co-operation.

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EROSION—A MAURITIAN MEASURE FOR PROTECTING WATER-COURSES

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IN tropical agriculture, water-courses are the scene of some of the deepest erosion and the loss of the most fertile section of the soil. In the Colony of Mauritius a simple legal enactment dating from 1875 has been effective, to a large extent, in preserving a vegetative cover on the banks of rivers and streams, and a note on the present position may usefully follow the series of articles on soil erosion published in past numbers of *The Tropical Agriculturist.*

The object of forming a river reserve along the banks of water-courses in Mauritius (see classification in a subsequent paragraph) are (i) to reduce the erosion of the banks and prevent damage by floods (ii.) to discourage the breeding of *Anopheles costalis* by ensuring a complete shade of trees or shrubs over the water (iii.) to improve a defective catchment and maintain a perennial flow without marked seasonal fluctuation and (iv.) to provide a refuge for insectivorous birds.

The desired results can, theoretically, be achieved by defining the river reserves and witholding them from sale when the adjoining blocks are opened up for agriculture : under this system the reserves are much exposed to pilfering of fuel, &c. and to encroachment, and a stage is usually reached at which encroachments have to be surveyed and sold to the owner of adjoining properties. The alternative, adopted in Mauritius, was to apply legal sanction to the use by the owner of the strip of land adjoining each bank and leave these strips in private ownership.

Water-courses are classified by proclamation as "rivers", with a 50-feet reserve on either side measured from the bank, "rivulets" with a 25-feet reserve and "feeders" with a 10-feet reserve. Within these limits no one may destroy or remove a tree, loiter in the reserve with a cutting instrument, set fire to vegetation, or plant other than approved tree species. Only perennial streams can be proclaimed in this way and erosion does, of course, occur in valleys and gullies which have only an intermittent flow. Marshes can be proclaimed as part of the

water-course and owners may clear brushwood, with permission, and plant useful and ornamental trees. The penalty for destroying, cutting, sawing or removing timber is a fine not exceeding Rs. 500 (£ 38) in addition to the payment of 3 times the value of the produce, and under these rules the actual owner of the reserve is as liable to these penalties as any outsider.

The law was probably drafted with direct reference to objects i. and iii. (erosion and catchment respectively enumerated above); malarial control was a later adjunct, and the protection of birds quite a recent after-thought. It is clear that objects i. and iii. can be achieved by a belt of shrubs or low cover, and it is found that *Eugenia jambosa* and *Ligustrum Walkeri* are excellent for the purpose. Tall trees, over 30 feet in height, very often *Tecoma pallida* or *Terminalia arjuna*, are unpopular with the owners of adjoining sugarcane plantations because of the excessive shade they provide and the serious interference of their root systems with the sugarcane crop: these disadvantages are held to outweigh any benefit which may be afforded by protection from wind or by the cooler and more humid atmospheric conditions which result from belts of this kind.

Uniformity is neither possible nor necessary, and after 60 years the 312 miles of 50-feet river reserves show a great variety of vegetation. Some reserves have been frankly encroached upon, others have lost their trees; but in very few cases and over quite short lengths have the banks been rendered liable to erosion. Many reserves for some miles on end have tall trees of *Tecoma* or *Arjuna*: in others which have *Rubus*, *Cordia interrupta*, or bamboo, erosion is as effectively checked. There can be no doubt that the measure has been strickingly successful with a low cost to the exchequer and the minimum of supervision. Control is exercised by a Board comprising the Heads of the Medical, the Police and the Forest Departments with a retired Forest Officer in executive charge while patrolling of reserves is carried out by the Police staff who are better distributed for the purpose than Forest Department staff as well as being more numerous.

A proposal has recently been revived for the re-definition and fuller utilization of some of the 50-feet reserves. Reserves in weeds or scrub of no value or those which have necessarily tall trees will, with the approval of the Board, be cleared in sections and replanted in fruit trees such as mango, litchi or citrus with such subsidiary crops as vanilla or cardamoms beneath them. Here again no uniformity is to be expected and some estate proprietors who protect their reserves at present with *Eugenia jambosa*, prefer the *status quo* to a mixed plantation of fruit which would be liable to pilfering. In the course of this reconstruction, the outer boundary of the reserves would be outlined in *Vetiveria* grass and any encroachments revealed in the

work would be included in the new plantations. Encroachments and areas degraded to a dense growth of weeds probably amount to 15 per cent. of the total and this considerable acreage can thus be reclaimed, restored to full efficiency and made to produce crops of some economic importance.

Viewed from high ground these reserves look like enormous hedges meandering through the cane fields and are a conspicuous feature of the landscape.

Mr. R. Thompson, Deputy Conservator of Forests, India, submitted a report in 1880 in which he stated "The River Reserves are one of the most important institutions in this Colony. Their existence has done much good in maintaining the water supply in the streams and rivers which they protect; and they are therefore worthy of imitation elsewhere."

At that time the reserves no doubt consisted chiefly of indigenous trees which are now less common: *Terminalia arjuna* dates from the time of Mr. Thompson's visit to Mauritius.

Similar rules apply to the protection of mountain reserves and, together, these classes cover about 9,070 acres. Crown forests (economic) and other forests including both mountain and river reserves amount to 97,225 acres or 21 per cent. of the total area of the Colony.

DEPARTMENTAL NOTES

TANNIA OR THE COCO-YAM

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MUCH has lately been spoken of the food value of the edible varieties of *Colocasias* and *Alocasias* which are known in different parts of the tropics under various names such as coco-yam, colalu, china-potato, dasheen, eddo, egypt-arum, gabi, kachchi, kachu, melanga, tannia, taro, talla, yautia and known in Ceylon as *alakola-ala, desai-ala, dehiala, gahala, habarala, kiri-ala, kandala, kokis-ala, rata-ala, sevel-ala, ratu-habarala, tummas-ala,* and *yakkala.*

In Ceylon these food plants have long been a common food of the people. The yams and, in some varieties, the leaves and stalks are cooked in many ways. However, as a food crop these yams have not attained the popularity they deserve on account of their potential value as a very nourishing, wholesome and palatable food. Few crops, if any, can surpass them for facility of cultivation, adaptability to varying conditions and production. The writer is aware of instances, where, under good cultivation, crops of 10–12 tons of yams per acre have been lifted. The yams or tubers of different varieties can be obtained from three months onwards to nine months after planting. The *tummas-ala* can be lifted in three months, the *dehiala* or *desai-ala* from the fourth month and the *gahala, rata-ala* or *alakola-ala* from the sixth month onwards. The great advantage of this crop is that it can be allowed to remain in the ground without serious deterioration of the crop for a considerable period, to be lifted as required. Another advantage is that, although there is a recognized time for planting yams, Tannias or Coco-yams can be planted almost throughout the year except in the very dry months and, therefore, an all-the-year-round supply of food can be obtained.

THE PLANT

The *Colocasias* and *Alocasias* are widely distributed herbacious perennials cultivated as annuals. The plant resembles the garden *Caladium*—see Figs. I., II. and III Macmillan says " There are two distinct forms (or genera) one of which is characterized by peltate leaves (petiole joined at a point towards centre of leaf), the other by hastate or sagittate leaves (arrow-shaped) with the petiole joined at the

leaf base, as in ordinary leaves. The latter form is usually placed under the genus Xanthosoma, which include *tannia, tanier, yautia, habarala,* &c. The under-ground tubers vary in size from that of a small to a medium-sized potato usually with a fibrous skin. Some varieties, however, produce few tubers or none, being grown for the tender leaves and shoots only, which are cooked and used as a vegetable. In other varieties, such as *desai-ala* of Ceylon and dasheen of Trinidad, both tubers and tender leaves are eaten." To this may be added that there are some varieties producing tubers from 6 to 9 inches long and 5 to 6 inches in diameter.

Several forms of the cultivated and the wild varieties of these plants are found in Ceylon from sea level to 5,000 feet. Some have dark green leaves, others very light green leaves and a third group which includes *kandala* and *ratu-habarala* purplish leaves and leaf stalks.

CULTIVATION

The plants are propagated by means of small tubers, large ones being cut into pieces containing two or three "eyes." The best soil for this crop is a sandy loam with a good proportion of organic matter. Hard, clayey soils or pure sandy ones should be avoided. Low-lying moist situations are favoured by such varieties as *habarala, sevel-ala* and those grown for their leaves. The *tummas-ala, rata-ala, dehi-ala* and *kandala* types of *gahala* prefer dry land and will do well under irrigation.

The soil should be worked to a depth of at least 12 inches. Planting distances vary from 2×2 feet to 4×4 feet according to the variety and conditions. If tubers are planted, they should be placed three to four inches deep. If crowns are used, about an inch of the top of the crown should be left above ground. Weeds should be kept under control until the plants grow up. It is important if, during the growing period, there is dry weather, to keep the soil moist as the plant grows best in damp soil. Few crops respond so well to manuring as *Tannias.* A heavy application of well-rotted farmyard manure or compost incorporated in the soil at the time it is being prepared for planting will almost double the yield of the tubers.

HARVESTING

The tubers are lifted from the third month onward according to the variety planted. In lifting, the whole plant should be dug without injuring the tubers. All the tubers should then be removed and the leaves and stalks chopped off almost to the head of the main root. The heads or crowns should be stored in a cool place until the time of planting.

As stated before, the tubers can be allowed to remain in the soil for a considerable time and dug up as required.

FIG. 1. A *Kandala* PLANT (PURPLISH LEAVED).

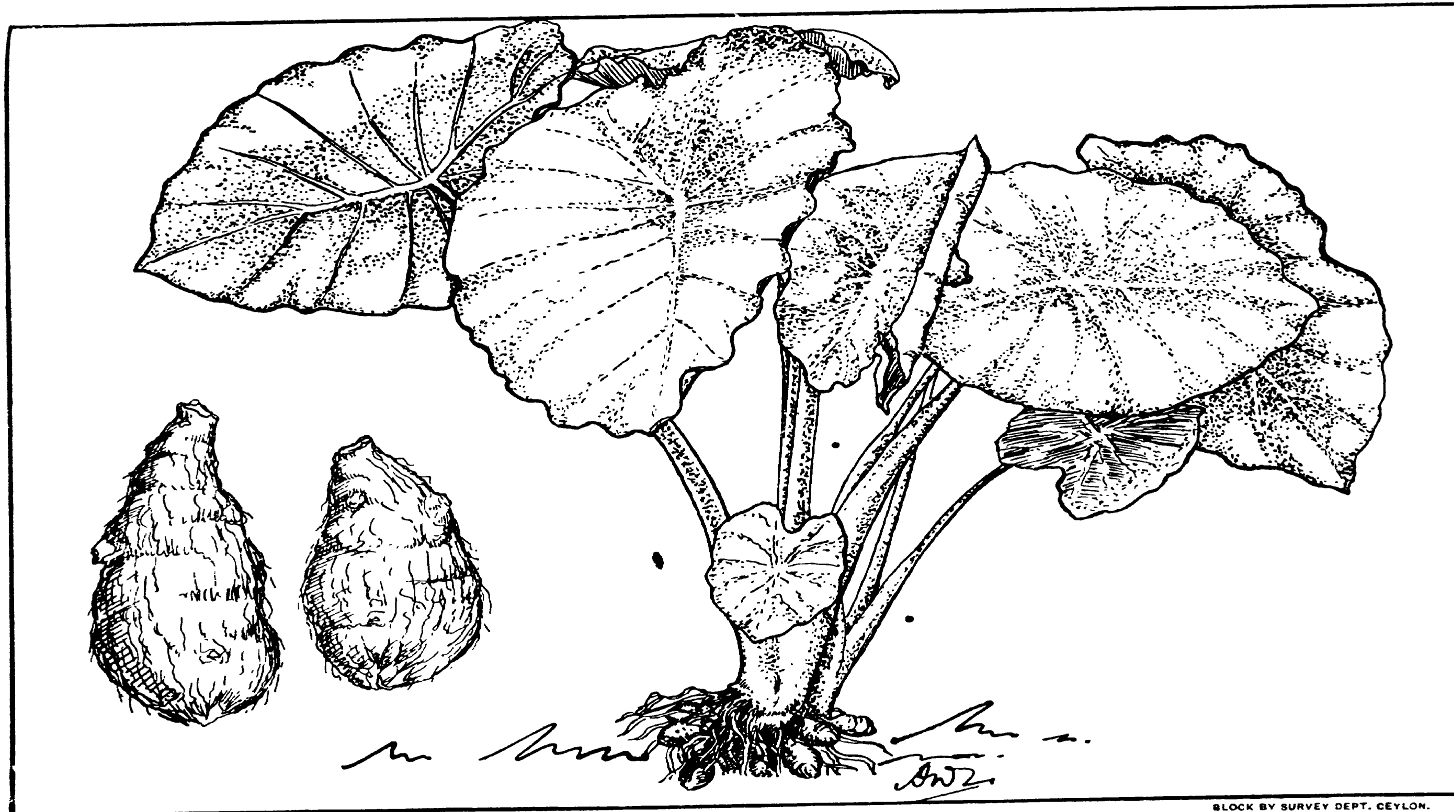

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FIG. II.—*Tummas-ala* PLANT AND TUBERS.

FIG. III.—A *Gahala* PLANT ALLOWED TO GROW FOR SEVERAL YEARS.

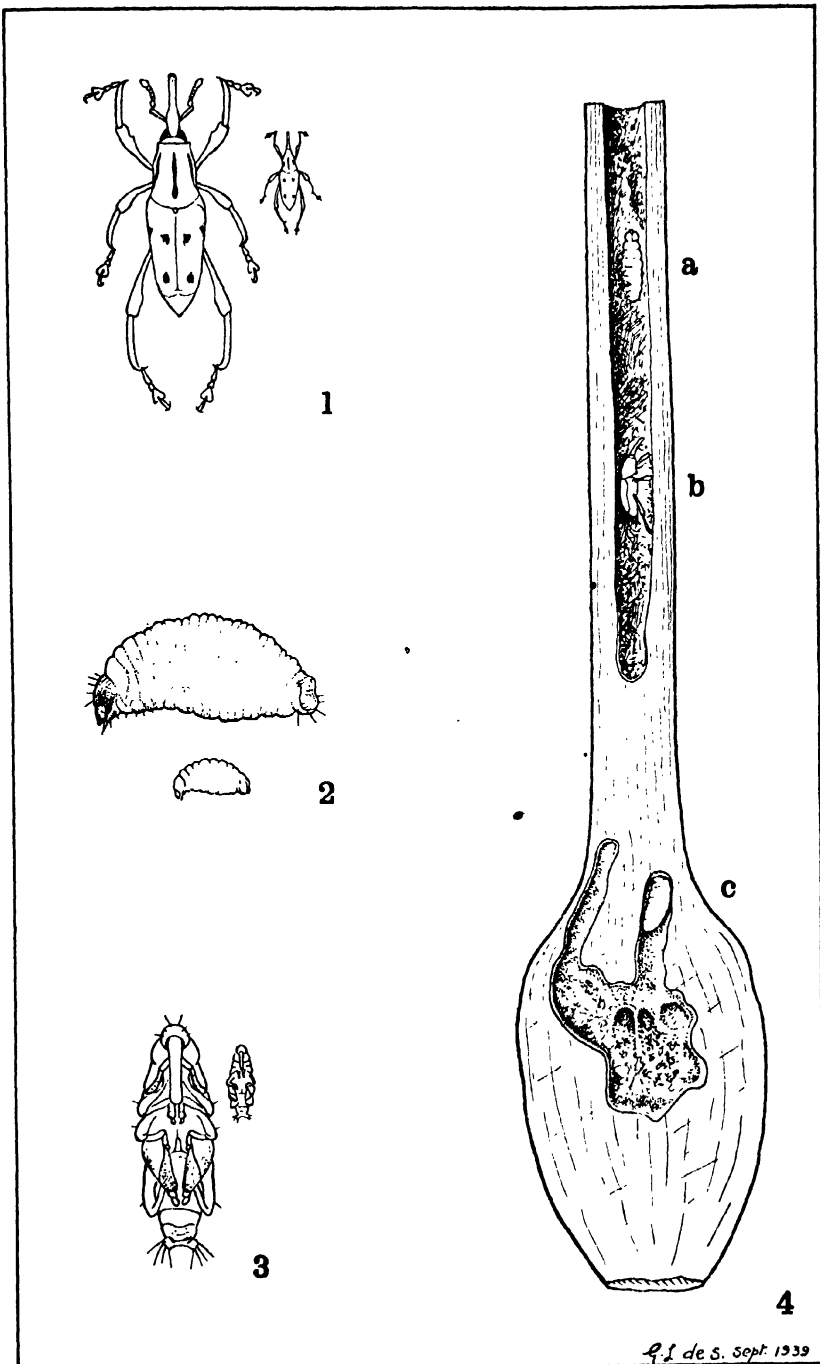
Habits and nature of damage.—So far as is known at present, no appreciable damage is done to cardamom plants by the weevil stage except the making of small feeding punctures and egg-pits with the proboscis. Eggs have not been found so far under field conditions, but the presence of grubs in separate tunnels in different parts of plants from the growing shoots down to the rhizomes indicates that the eggs may be laid almost anywhere in the softer tissues of the plants. Judging by the egg-laying habits of related weevils, such as the red weevil of coconuts and the black plantain weevils, it is probable that the small, soft, whitish, elongate eggs are deposited by the female in cleverly concealed pits previously excavated with her proboscis. The weevils usually hide in sheltered places on the plants and on the ground during the day and are active at night. When disturbed on a plant they draw in their legs close to the body, drop to the ground and pretend to be dead for a short time, after which they take shelter, moving forwards with a characteristic jerky gait.

The larva or immature stage is a soft, creamy, legless grub with a brown head and powerful biting jaws and a rather stout, much wrinkled body (fig. 2). The grubs feed entirely inside the plants, which may be riddled from top to bottom, including the rhizomes (fig. 4) when some half-a-dozen grubs are found in the same plant. Individual plants in a clump may be killed, and during a heavy infestation, such as was observed recently on a Dolosbage estate, every plant in a clump may be killed gradually, so that there is a complete failure of young shoots, racemes and subsequent crop. The damage caused by these grubs is far more serious than that done by the caterpillar stem-borer, which usually confines its activities to the shoots and stems and rarely penetrates the rhizomes.

The full-grown grubs change into the pupal stage (fig. 3) inside the hollow stem or in enlarged cells in the rhizomes. Apparently no special cocoon is made by the grub, as in the case of the red weevil and the plantain stem-borer, but individual pupae may be loosely surrounded by frass and fibres. The weevils emerge later, but remain inside the cell (fig. 4b) until the body-covering has attained its final colour and hardness; then they bore their way out and begin their active life of feeding and reproduction. At present, nothing is known about the length of the life-cycle, but it probably occupies at least 4–6 weeks.

RECORDED CEYLON DISTRIBUTION OF WEEVIL.

Galagedera, October, 1900 (cardamoms)*; *Kandy,* August, '03, January '11*, August and September '14, November '30, May '33; *Urugala,* September '22, April '23, April '24 (cardamoms); *Gammaduwa,* November '29, September '32,



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THE CARDAMOM WEEVIL (*Prodioctes hæmaticus* Chev. var.).

Figure 1.—Weevil. Figure 2.—Full-grown grub. Figure 3.—Pupa. Figure 4.—Section of portion of cardamom

May '33, November '33 ; *Nitre Cave,* April '30 ; *Kitulgala,* April '27 ; Ratnapura, September '12*, *Rakwana,* May '29 ; *Dolosbage,* August '39 (cardamoms)*.

The four records in the Peradeniya collection are marked with an asterisk (*) ; for the remaining locality records we are much indebted to the Director, Colombo Museum, who has kindly supplied the information from the specimens in the Museum collection, with notes on the host plant where available. It will be seen that the insect now to be known as the cardamom weevil was recorded nearly 40 years ago from the Galagedera district where it was said to damage cardamoms, but there is no evidence that it was a pest at that time. Apart from the recent outbreak in the Dolosbage district, the only other record from cardamoms is from the Urugala district in April, 1924. Estates which are known to grow cardamoms are being circularised with a request for any available information on this weevil, and field officers of the Department are being requested to be on the look out for it in village areas of cardamoms and related crops. Inquiries are also being made in India and at the Imperial Institute of Entomology, London.

Food plants.—The locality records are nearly all from districts in which cardamoms are grown and it is probable that this crop is normally used by the weevil as a food and breeding plant. Further investigations may indicate that the related wild and cultivated species of ginger, turmeric, plantain, &c., are possible alternate food plants, if not actually breeding plants.

Suggested control measures.—The withering and death of the growing shoot is usually an indication of attack by this weevil or by the caterpillar borer. All attacked plants including the rhizomes, where necessary, should be removed and burnt or otherwise effectively destroyed, so as to prevent the further development of the immature stages of the pest and kill any weevils sheltering inside the plants prior to emergence. In badly attacked patches whole clumps may have to be treated in this way, care being taken to remove from the soil all pieces of rhizomes and roots. While clearing up any heavily infested patches, small heaps of this refuse material can be used as traps to attract the weevils which should be collected and destroyed wherever found. For replanting, only sound rhizomes from a non-infested area should be used.

SEASONAL PLANTING NOTES

CALENDAR OF WORK FOR JANUARY

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THE opening month of the year is, from the gardening point of view, a busy and an interesting one. The rainfall generally throughout the country is diminishing and the temperature cool and refreshing.

Most planting operations in the low-country will have been finished, and vegetables planted in the early north-east season should be ready for cropping, but there is yet time for sowing and raising the quicker-growing food crop varieties. A good stock of yams should be selected and stored for March-April planting, whilst tomatoes now in full growth should be staked and side shoots thinned out. Annuals and perennials in the flower garden should now be approaching their best.

In the northern parts of the Island, similar operations can be undertaken and planting of tobacco seedlings, chillies, brinjals, plantain suckers and betel vines can be made early in the month. In mid-country districts, plantings of bed and border plants and vegetables can proceed when rain has set in. With the quick-growing varieties of vegetable and flowering annuals, it is generally quite easy to obtain the result of three successive sowings before the dry weather sets in if sowings are made in mid October, late November and early January.

Up-country conditions are yet wet and misty in the early part of the month but improve towards the end of the month. This improvement is, however, usually accompanied by light frosts which should be guarded against. Planting of flower beds should have ceased by the end of the month and all beds and borders should now be forked and weeded, a very necessary operation after heavy monsoon periods, allowing aeration of the soil. Towards the end of the month and early next month, mulching with leaf or jungle mould with a proportion of well-decayed cattle manure can be given to all plants with very beneficial results. Weather should now be excellent for regular sowings of most vegetables,

and such sowings, made in succession, can continue for several months. Excellent crops of peas, beans, broad beans and cauliflower can be raised from now onward to mid May next. Strawberries, too, are a very profitable crop for the local markets in and around Nuwara Eliya, and should be tried wherever possible. As before mentioned, this month is an interesting one to all keen gardeners and chiefly by reason of the fact that the cooler and more favourable weather conditions at this time of the year allow a fairly wide range of subjects to be exploited and tried out. The lawns, too, are generally in the best possible condition as a result of the late monsoon rains.

Bearing this in mind the sympathies of the true gardener go to all those who are compelled to live in the city or any large town where land values permit of a garden only of microscopic dimensions. The variety of colour to be obtained in bed and border assortments set in a sward of green turf is not for him or her. The bungalow outlook often comprises a nearby brick boundary wall and a few large trees planted for shade purposes and whose root system effectively prohibits any form of bed or border planting in the limited bungalow environments. It is hard to be an enthusiastic gardener under such conditions, yet there are many such, and their gardening abilities are directed, necessarily in this case, to the form of gardening known as pot and verandah gardening.

It is in fact surprising what can be done in this respect and generally by way of pot plants on the verandah, on stands outside, on pillars here and there, or clumps of pot or box plants around tree stems or arranged against a wall. All foliagd plants such as palms and ferns, can be very satisfactorily usec in this way, as well as many flowering annuals and a few perennials, if planted in either pots or boxes. Pots deeper than the normal should be used as this avoids too frequent repotting and allows room for strong-rooted plants to penetrate downwards. The best palms for such work are *Chrysaildocarpus* (the cane palm) *Ptychosperma*, *Archontophoenix*, *Kentia* and the small *Areca* of the feather-leaved varieties, with *Licuala* (the fan palm), *Brahia*, *Livistona*, *Pritchardia*, *Sabal*, *Thrinax* and the small South China *Rhapis* of the fan palm group. All are easily grown and of much merit for this type of gardening.

Ferns are desirable in any group of plants on account of their gracefulness of foliage. They love shade and the selection given last month for fernery purposes should do well if full use is made of the smaller varieties such as *Adiantum* (Maidenhair fern) *Pteris* and *Asplenium* varieties. The Fijian fern, *Davallia*, does especially well if suspended in a ball of its own roots from verandah frontages or from tree branches.

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The skill in this type of gardening, however, is indicated in the show that can be made of the flowering annuals and perennials.

Good-sized and deep pots, 12″ or so in diameter, or boxes, if larger receptacles are required, that hold some depth of soil should be used. The soil mixture for ferns would, as before indicated, comprise a good portion of leaf-mould, but with palms and flowering plants a heavier mixture is required, and equal parts of good garden soil, cattle manure and leaf-mould, with a proportion of sand equal to a quarter inch dressing of the pot or box surface should be added when mixing. With perennials, cuttings could be inserted direct, or preferably rooted plants from a nursery should be used. With annuals these would presumably have been raised in beds or boxes and should be planted out into the pots in which they are to flower at distances according to type of plant used.

With achemenes, for instance, 12 bulbs per pot would be best whilst with such as petunia or begonia 3 seedlings or cuttings should suffice. The grower must use his own discretion, of course, as to spacing according to the requirements and stature of the plant being grown. Some growers prefer to grow the plants singly in pots in which case a 4″ to 6″ pot is large enough for the smaller type and 8″ to 10″ for the larger. In any case plants grown in pots, singly or in groups, must be fed and when the pot or box has become fully pot-bound, usually at the maximum period of growth and before flowering, they should be fed with liquid manure to obtain the best results.

The following list gives roughly the varieties suited to this form of culture and the requirements as to spacing when planting :—

At 12 to the normal 12″ pot, achemenes and violets ;

At 6 to the pot, aster, candytuft, dianthus, fittonia, mysotis, *Phlox Drummondii*, torenia, violet and zephyranthus (bulbs).

At 3 seedlings or cuttings to the pot the following are suited :— begonia, caladium, carnations (cuttings), coleus, coreopsis, costus, geraniums (cuttings), impatiens, isoloma, petunia (cuttings), saintpaulia and verbena (cuttings). For single pot work a good selection includes alocasia, angelonia, antirrhinum, anthurium, calathea, celosia, chrysanthemum, dahlia, gerbera, hollyhock, maranta and salvia, though there are others also.

The main points to remember in this type of gardening are that good drainage is arranged for and that the plants in the younger stages of growth should not be over-watered. Later, when the pots or boxes become potbound, copious supplies of water are required and every third watering should be with

manure water. Manure water of average good strength suitable for most strong-growing pot plants can be made by putting half a bushel of good cattle manure in a sack and allowing this, with occasional stirrings, to remain for 24 hours in a small tank or barrel holding 15 to 16 gallons of water. The mixture should be stirred again at the time of using and, if possible, fresh stocks may be made daily. For very robust plants such as chrysanthemums, the strength can be increased by a larger amount of manure in the sack, but on the other hand with the more tender or weaker-rooted plants the normal strength can be reduced by dilution with water at the time of watering.

If larger receptacles are available, such as tar, oil, or cement barrels, and these are cut in half and thoroughly cleaned, the range of varieties may be increased, for bougainvillaeas, brunfelsias, ixoras and similar shrubs of a large type can be grown and flower very satisfactorily in this way. A good watch should be kept for insect attacks and remedies applied immediately. Generally speaking the old-fashioned kerosene emulsion is a useful spray to apply once a week, whether attack is perceptible or not. This keeps down scale and the attacks of other insects which are often not noticed in the early stages. For leaf-eating insects lead arsenate should be used, and for leaf-miner attacks nicotine sulphate is a good remedy and preventive. Where mildew appears, as it often does in the young seedling stages, the plants should occasionally be dusted with flowers of sulphur.

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SELECTED ARTICLES

THE WORLD'S CINCHONA BARK INDUSTRY—I GENERAL CONSIDERATIONS*

At the present time by far the greater part of the world's output of cinchona bark is produced in the Netherlands East Indies. The most important, in fact about the only, producing country in the British Empire is India, but that country still has to import large quantities of quinine in order to meet the requirements of its sufferers from malaria who are estimated to amount to some 100,000,000 at any particular time. India, too, is the only Empire country, other than the United Kingdom, which possesses factories for the manufacture of quinine from the bark.

The question of making the Empire self-sufficient in the matter of cinchona and quinine, or at least of very greatly increasing production in the Empire, is therefore one of considerable importance.

The Netherlands East Indies are particularly favourably situated for the production of cinchona. The climate and soil of the Preanger Residency in Java, where most of the estates are situated, are ideal for the growth of the tree, whilst the Government and planters have behind them well over half a century of experience based on a profound scientific study of the cultivation and improvement of the tree. Any British country would therefore be at a disadvantage in competition with the Dutch producers. Against this, however, it has been urged that the question of supplies of febrifuge for the treatment of malaria is not one to be determined solely by economic considerations.

Apart from India, the most promising parts of the Empire for cinchona production appear to be Malaya, Tanganyika and the Cameroons under British Mandate. Experimental work has been carried out in these countries indicating that areas exist suitable for cultivation with cinchona and in the two last-named plantations had already been established by the Germans before the war.

The possibilities of producing cinchona in the Empire, particularly in East Africa, have for some years past been a special concern of the Colonial Advisory Council of Agriculture and Animal Health. In 1932 a Sub-Committee of the Council, after considering the relevant facts, reported against any immediate extension of cinchona production, one important reason being the fact that synthetic febrifuge drugs (plasmoquine, atebrine, &c.) were being manufactured,

* Extract from *Bulletin of the Imperial Institute*, Vol. XXXVII. No. 1. (January-March 1939).

and it was thought at the time that developments were likely in the near future which would result in the extensive adoption of synthetic products more efficacious than quinine, rendering increased supplies of quinine unnecessary.

However, synthetic febrifuges have not yet become generally available at prices that would compete with quinine, and, moreover, it would seem that the use of such drugs is attended with some risks, for which reason they cannot be distributed generally for use without medical supervision. Accordingly in 1935 the question was again considered by a Sub-Committee of the Colonial Advisory Council, who this time reported that despite the progress made in the production of synthetic anti-malarial compounds it was probable that for many years to come large quantities of quinine would be necessary and that in the circumstances the production of quinine in the Colonial Empire ought to be encouraged.

In investigating possibilities in different countries it is recognized that trials need not be limited to the species richest in quinine, *viz.*, *Cinchona ledgeriana*, which is particularly exacting in its requirements as to soil, temperature, moisture and altitude, but that in some districts it may be more advantageous to grow other species better suited to the locality even though their yields of quinine may be lower. In this connection the question had come to the fore of using the " mixed alkaloids " of cinchona instead of separating quinine from the other alkaloids (quinidine, cinchonine, cinchonidine, &c.) with which it is associated. This considerably reduces the cost of extraction and also involves less complicated technical processes. Such mixtures have been prepared under the name " totaquina ". In view of the variation in proportions of the various alkaloids in the barks of different species it is necessary that such a product should be to some extent standardized, and, according to the specification of the Malaria Commission of the League of Nations, totaquina must contain at least 70 per cent., of crystalline alkaloids, of which not less than 15 per cent. must be quinine, amorphous alkaloids not exceeding 20 per cent. These requirements permit of the preparation of totaquina from barks of comparatively low quinine content, such as *C. succirubra*. The nature of the totaquina obtained from the bark of this species, however, differs from that which can be prepared from *C. ledgeriana* and further information as to its efficacy is required. The Cinchona Sub-Committee of the Colonial Advisory Council have expressed the view that until the results of further medical trials are forthcoming it is impossible to pronounce an opinion as to whether it would be desirable to concentrate on the cultivation of *C. succirubra* for the preparation of one kind of totaquina or of *C. ledgeriana* for the production of quinine or what has been called " totaquina type 2."

As regards the position of experimentation in the Colonial Empire, the Cinchona Sub-Committee, in a report submitted to the Colonial Advisory Council at a meeting held on October 21, 1936, indicated that, on the evidence then available, it appeared that cinchona could be grown satisfactorily in the Usambara Hills in Tanganyika. It was not, however, considered that, at the present stage, it would be desirable to embark on a large state-owned plantation enterprise. It was pointed out that provision had been made for the establishment of 100 acres of cinchona at Kwamkora adjoining Amani, and at the same

time there was evidence that provided planting material could be made available at reasonable rates coffee estates in the Usambaras might be prepared to undertake cinchona cultivation. The Committee considered that the position in the Territory should be re-examined at the end of five years, by which time further evidence should have become available.

The Committee recommended that in Kenya and the Cameroons under British Mandate experimental trials should be undertaken, possibly on the lines which have been decided in Malaya, where a number of trial plots of different types of cinchona are being established in various parts of the Cameron Highlands.

In recent years the production of cinchona bark in the Colonial Empire has been considered rather from the point of view of providing raw material for the febrifuge needed by the local inhabitants than of producing bark to compete in the world's market with the Java product. The question thus arises of the location of the factory for making quinine. Such a factory needs the constant supervision of a fully-qualified and experienced scientific and technical staff, which naturally increases the overhead charges. At the same time the essential need is for a supply of quinine cheap enough to be within reach of the poorest sufferers from malaria. The Superintendent of Cinchona Cultivation in Bengal has expressed the opinion that the smallest factory unit which could be run economically should have an output in the neighbourhood of 15,000 lb. of quinine sulphate a year and that a production of substantially less than this amount would scarcely justify the maintenance of the necessary expert staff. The bark produced on an area of about 120 acres would be required each year to meet the demands of a factory of this size, so that on a 10-year rotation plantations occupying an area of 1,200 acres would be necessary for each factory.

The Cinchona Sub-Committee consider that Malaya is the only country in which the consumption of quinine is at present sufficient to justify the erection of an economic factory unit. It has been suggested that bark produced in all the African colonies should be treated at a factory, or factories, in East Africa, but this is regarded as being impracticable. An alternative suggestion is that manufacture might be centralised in the United Kingdom and in the view of the Sub-Committee this appears to have a good deal more to commend it.

SPECIES OF CINCHONA : THEIR ALKALOID CONTENT AND CULTURAL REQIREMENTS

The genus *Cinchona*, belonging to the natural order *Rubiaceæ*, comprises a number of species, mostly small trees, which are native to the mountains of tropical South America between the latitudes 10° N. and 19° S. The classification of the group has presented considerable difficulty to botanists, owing to the facility with which the species hybridise with one another, giving rise to many different forms.

Four species only have been cultivated to any extent as a source of alkaloids. These are : *C. ledgeriana* Moens ex Trimen (known also as *C. calisaya* Wedd. var. *ledgeriana* Howard), from which Ledger Bark is obtained, *C. succirubra* Pavon

ex Klotzsch, the source of Red Bark, and finally *C. calisaya* Wedd. and *C .officinalis* Linn., yielding Yellow Bark and Crown Bark or Loxa respectively. Two hybrids may also be mentioned, namely, *ledgeriana* × *succirubra*, known as Ledger Hybrid or sometimes as *C. hybrida*, and *officinalis* × *succirubra*, which is usually called *C. robusta*. At the present time practically the entire supply of cinchona bark in commerce is obtained from *C. ledgeriana* and *C. succirubra*.

There is a wide range in the alkaloid content of the barks from different species and from different strains of the same species, while even within a single strain the percentage found is subject to considerable variation, depending upon climatic and soil conditions and also on the age and state of the tree. In the individual plants the alkaloid content increases up to the age of approximately eight or ten years, the time being partly dependent on soil and other external conditions ; after this the bark tends to become poorer in alkaloids and in an old tree the decrease may be quite marked. This falling off in alkaloid content is noticeably earlier in trees which show premature flowering. Of the distribution in different parts of the tree it may be said that the rootbark is normally richest in total alkaloids, while the bark at the base of the trunk contains a slightly lower proportion, which gradually decreases upwards to the branches. This condition is not necessarily true of individual alkaloids, which sometimes show a tendency to concentration in the bark of the trunk, as is the case with quinine in *C. ledgeriana*. In a plant of this species the alkaloids of the stem-bark may consist of nearly 90 per cent. of quinine, while those of the root-bark contain about 60 per cent.

Not only does the total alkaloid content vary with the different species and strains, but also the relative proportions in which the different alkaloids are present. This proportional composition of the total alkaloid in the bark is, however, more or less characteristic for each species, although by no means constant.

The following table gives an indication of the usual range of alkaloid content in the barks of the principal species and hybrids now cultivated. The composition of bark from hybrid plants is particularly liable to variation.

Alkaloid Content of the Barks of different Species of Cinchona.

	Total Alkaloids.	Quinine.	Cinchonidine.	Quinidine.	Cinchonine.	Amorphous Alkaloids.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Species :						
C. ledgeriana	5–14	3–13	0–2·5	0–0·5	0–1·5	0·2–2
C. calisaya	3–7	0–4	0–2	0–3	0 3–2	0·2–2
C. succirubra	4·5–8·5	1–3	1–5	0–0·3	1–2·5	0·3–2
C. officinalis	5–8	2–7·5	0–3	0–0·3	0–3	0–1·5
Hybrids						
C. ledgeriana × *C. succirubra* ("*C. hybrida*")	6–12	3–9	0–3	0	0·5–1·5	1–2.5
C. officinalis × *C. succiruba* ("*C. robusta*")	6–8·5	1·8	2·5 6·5	0–trace	0–1	1·2

It will be seen that, generally speaking, the bark of *C. ledgeriana* is richer in quinine than that of any other species, while *C. succirubra* may have a high content of total alkaloids and is sometimes particularly rich in cinchonidine. The Ledger hybrid, resulting from the cross of these two species, has also produced bark with a very high content of quinine.

It must be borne in mind, however, that a high alkaloid content is of little value if the yield of bark is poor and the latter factor must therefore be taken into consideration in selecting species for cultivation. In addition, cultural problems are obviously of vital importance and here it may be mentioned that *C. ledgeriana* is often extremely difficult to rear in some regions where other species will grow vigorously.

The natural distribution of the genus *Cinchona*, taken as a whole, covers a very limited geographical area, and it is found that in cultivation the different species have similar climatic requirements. Summarized briefly, the most suitable conditions are a tropical climate and an elevation of from 3,000 to 6,000 ft.; a fairly high average temperature with relatively small range of variation, high atmospheric humidity, high rainfall well distributed throughout the year, a light well-drained soil rich in organic matter, and a sloping situation but sheltered from the wind. Generally speaking, the ecological conditions favourable for the growth of cinchona are those which would support a natural vegetation of evergreen rain forest.

As a concrete example may be quoted the climate of Java, which is eminently suited to the cultivation of cinchona. The rainfall in the cinchona growing areas is between 100 and 150 in. annually, with about three months of relatively dry weather, and the average relative humidity is over 70 per cent. at mid-day and over 90 per cent. in the morning and evening, the plantations frequently being enveloped in cloud. The mean monthly temperatures at different times of the year vary only between 68° and 73°F.

The cultivation of most species of *Cinchona* is not, however, strictly limited to conditions such as these, as some have been grown successfully in a much drier climate, as that of Madras where the annual rainfall is only 45 in. and considerable periods of drought occur. Unsuitable conditions may, however, influence the content of alkaloids, even though the plants appear healthy. This is the case with low altitudes, where the trees will grow vigorously, but may have a greatly reduced yield of quinine and in addition are short-lived and more susceptible to disease. At higher altitudes again the yield is reduced, but here growth is slow and the plants are easily killed by frost. Generally speaking, *C. officinalis* succeeds better than other species at high altitudes, while *C. succirubra* is the most accommodating species.

It has already been mentioned that *C. ledgeriana* is more exacting in its requirements than any other species. The most suitable climatic conditions for satisfactory bark production of high quinine content would appear to be those obtaining in Java at elevations of 4,000 to 5,000 ft. The character of the soil is also of great importance in the case of this species; its first essentials are that it should be friable and of good depth, the best results in Java having been obtained on such soils, recently clear of forest. Other species, especially

C. succirubra, on the other hand, will thrive and give relatively good yields of alkaloids under conditions where *C. ledgeriana* would fail. For this reason and owing to the uncertainty of successfully re-establishing *ledgeriana* on old cinchona lands attention has been paid to the question of grafting the latter species on the more vigorous *succirubra* stock. This has proved highly successful and practically all the Ledger bark now being produced in Java is harvested from grafted trees.

Little is recorded about the requirements of the Ledger Hybrid (" *C. hybrida*") which has given such promising bark-analyses. It has been grown in Java both on its own root and grafted on to *succirubra*, but it is now largely replaced by grafted *ledgeriana* and is no longer cultivated to any great extent.

As regards propagation, vegetative methods are preferable, as the progeny from seed is apt to be unreliable unless special precautions are taken owing to the occurrence of hybridization between different strains and species. In Java plants which are specially selected for their high yield of quinine are grown for seed in gardens isolated from the rest of the crop, where there can be no risk of contamination.

Direct shade is said to be generally harmful to the young trees, but belts of virgin forest between the plantations are helpful in maintaining the necessary humidity of the atmosphere.

THE PRESENT POSITION OF THE PRODUCTION OF CINCHONA BARK AND QUININE

In the following account of the state of cinchona production and experimentation in the different countries of the world, the Netherlands East Indies, from its pre-eminence in the industry, is dealt with first, followed by India, the most important Empire producer. Particulars of the work which has been done in other Empire and foreign countries will be given in the next issue of this BULLETIN.

NETHERLANDS EAST INDIES

The exact area under cinchona in the Netherlands East Indies cannot be given, as the official statistics relate only to such estates as send in returns. In 1937, 105 estates made returns, of which 101 were in bearing. Of these 105, 96 are situated in Java (44 in Preanger Residency and 24 in Buitenzorg); the other 9 are in Sumatra. The total area planted with cinchona on these estates was 42,489 acres (37,358 acres in bearing), and the amount of dry bark harvested was 22,975,981 lb., which probably represents about 90 per cent. of the total production of the country. It is believed that there has been more expansion in planting in the Netherlands East Indies in recent years than is indicated by the official figures and the Government has appointed a Commission to investigate the whole position of the industry.

It is estimated that the Netherlands East Indies now produce over nine-tenths of the world's supply of cinchona bark. This extraordinarily strong position has been attained not only as a result of favourable climatic conditions, but also through the systematic thoroughness with which the industry has been

carried on from the start. The earlier work was of particular importance as it laid down the lines for future development, and the rapid rise of the industry owes a special debt to the scientific insight of Moens, who played a prominent part in the direction of the Government Cinchona Plantations during this early period.

One of the first problems which engaged the attention of the Dutch growers was that of determining which of the various introduced species would give sufficiently high yields of alkaloid to repay cultivation on a large scale. The first analyses of Javan Ledger Bark in 1872 gave a solution to this problem, for the significance of its high quinine content was quickly realized and attention was thenceforth centred on the cultivation and improvement of *ledgeriana* for quinine production. It was the success of this policy which played a large part in bringing about the downfall of the cinchona industry in Ceylon, where *succirubra* was grown. The high yields of quinine obtained from *ledgeriana*, and the prominence accorded to this alkaloid, rather to the neglect of other cinchona alkaloids, made it impossible for *succirubra*, with its lower proportion of quinine, to compete under difficult market conditions.

Over a period of many years the methods of cultivation and propagation in the Netherlands East Indies have been steadily improved by the experimental work carried out on the Government Cinchona Plantations at Tjinjerœan. The original Ledger plants were of very mixed character, but scientific reasearch and rigorous control in the selection and breeding of new high-yielding varieties have given a stock of the highest quality. It is interesting to note in this connection that as early as 1878 a quinine content in the bark of 9 to 10 per cent. or more was demanded on the Government plantations for trees from which seeds or cuttings were taken for propagation. In the earlier selection work the value of the trees was assessed principally by the percentage content of quinine found in the bark, and little or no account was taken of such factors as the thickness of the bark or its rate of growth, which greatly influence the total yield of quinine. It is only within the last 25 years that a satisfactory quantitative method of estimating the yield of alkaloids has been devised, thus putting the later selection work on a sounder basis.

Another important aspect of the Dutch work relates to the problem of continuous cultivation of cinchona on the same soil. Mention has already been made of the difficulty of growing *ledgeriana* on old soils, and of the introduction of a grafting technique whereby *ledgeriana* scions could be grown on stocks of the more robust species such as *succirubra*. This provided a means of combining the high-yielding qualities of the former species with the hardiness of the latter, but did not remove the problem of soil deterioration. Erosion losses have now been largely prevented by terracing and the provision of adequate drainage, and various manurial treatments have been applied to improve the soil. Leguminous cover-crops are being grown as green manure between the rows of cinchona plants on the young plantations, whilst for regenerating old cinchona land the growing of a green manure crop for two or three years before replanting has been suggested. Although the earlier experiments with artificial manures seem to have been inconclusive, more recent work in this direction has indicated the advantage of using fertilizers, particularly nitrogen and phosphate manures,

where the fertility of the soil has become depleted. Generally speaking, however, the soil fertility in Java is naturally high and the addition of artificial fertilizers is unnecessary.

Mention must also be made of the strong economic position of the industry in the Netherlands East Indies, which is maintained by co-operation between the growers and quinine manufacturers through the " Cinchona Agreement " of 1913. Prior to this agreement there were periods of overproduction when the price of the bark fell so low that the industry was threatened with extinction. Since 1913, however, the supply of bark has been regulated according to the demand and in this way prices have been maintained at an economic level and the position of the growers stablized. The administration of the Cinchona Agreement lies with the Kina Bureau in Amsterdam, which is made up of representatives of the growers and the quinine manufacturers. As about 10 per cent. of the total bark production of Java is from plantations directly controlled by the Government it will be seen that the Government influence in this Agreement is of some importance.

Since early in 1934 the production of bark has been further regulated by the introduction of an export quota system. The Government decrees annually the maximum amount of cinchona, expressed as quinine sulphate, that shall be provided with export licences, but provision is made for increasing the amount should the demand for quinine warrant such action.

In 1935 the quantity of bark handled under licence was 20,273,686 lb. (equivalent to 1,408,752 lb. of quinine sulphate), of which about 82 per cent. was intended for shipment overseas and the remainder used in the quinine factory at Bandœng.

For 1936 the export quota was fixed at 1,646,851 lb. (expressed as quinine sulphate equivalent), but in order to meet the heavy demand for quinine throughout the world the quota was increased in November by 157,630 lb. The export quota for 1937 was fixed at 1,470,481 lb. (quinine sulphate equivalent), a considerably lower figure than for the previous year. The quotas for 1938 and 1939 have been progressively lower. The producers of bark have benefited greatly by this restriction scheme, and on the recommendation of a Committee appointed to investigate its working it was decided to extend the scheme for a further ten years from January 1, 1937.

In 1936 the quinine industry of the Netherlands East Indies enjoyed the greatest prosperity that it has had since 1930. The exports of bark in 1936 amounted to 19,978,463 lb. (£1,026,012) and of quinine 6,774,646 oz. (£411,584). During 1937 shipments of bark were substantially less than during 1936, but exports of quinine rose somewhat. Shipments of bark rose again in 1938, but those of quinine were smaller. The actual figures were : 1937, bark 13,961,831 lb. (£736,349), quinine 7,329,152 oz. (£409,446) ; 1938, bark 15,337,801 lb. (£919,721), quinine 6,430,407 oz. (£395,112).

INDIA

During the earlier period of cinchona cultivation the Indian policy aimed at building up an industry which would supply sufficient quinine to meet the country's needs. With the rise in importance of the industry in Java this ideal

was gradually abandoned, but it revived with the War conditions and by 1917–18 the possibility of making the whole Empire self-sufficient, largely through India's supplies, was under serious consideration. At this time the reserve stocks of quinine held by the Government of India had been considerably depleted, and for a number of years it was necessary to supplement the production of the bark with supplies imported from Java. It has not, however, been found practicable under existing conditions to produce quinine in India at prices which will compete with Java and the output still falls far short of the present requirements of the country. The need for increased supplies of cheap quinine and the difficulties in the way of meeting the demand are discussed by C. C. Calder, the Superintendent of Cinchona Cultivation in Bengal, in his Annual Report for the year 1935–36, from which the following extracts may be quoted :

" The present high level of prices in cinchona products is essentially due to the difficulties of production. If the raw material were easy of production the manufacture of sufficient supplies of quinine would be easy enough, but cinchona as a plant is exacting in its demand and it is not everywhere or under any set of conditions that it can be successfully exploited. Costs of production are high, competition is restricted by reason of the climatic and soil requirements of cinchona and these combined explain high world prices.

" It is fortunate that in India areas exist fairly suitable to the cinchona plant and experience has shown that it can be cultivated here at costs which would allow of a cheapening of quinine for the masses. When the public recognize this fact and finance is forthcoming there is no reason why a forward cinchona policy should not be adopted with every prospect of success. Experimental cultivation could be started under suitable conditions in different parts of the country, and all the accumulated experience of the existing cinchona organizations in India would be available to draw upon. But the success of such effort, if it is truly national, would seem to depend on a co-ordination of all the provincial efforts. Only certain provinces in India, however, are fortunate in having suitable areas, and with the inauguration of provincial autonomy under the new constitution it would seem that the Central Government alone could bear the responsibility of such a national policy, so that the less fortunate provinces also may benefit. For under the present economic conditions it is not likely nor is it reasonable to ask that those provinces which can produce would make revenue sacrifices in the interest of others."

During the last few years the position of the industry has changed but little, and production of the bark is still practically confined to Bengal and Madras. It has recently been reported, however, that the Government of Assam has under consideration an experimental cinchona plantation scheme extending over an area of 15 to 25 acres. A number of trees are stated to have been planted already on a 4-acre plot near Nongphoh. The plantations in Lower Burma will be discussed separately in the subsequent part of this article.

The areas under cinchona on the Government plantations of Bengal and Madras, as given in the annual reports for the last three years available, are shown in the following table. This does not include plantations under private ownership.

Area under Cinchona on Government Plantations
(Acres)

	Bengal.	Madras.
1934-5	2,585	1,942
1935-6	2,664	1,949
1936-7	2,762	1,991

No statistics are available for the total production of bark in India, but the quantities collected on the Government plantations attached to the quinine factories in Bengal and Madras in the last three years for which figures are available have been as follows :—

	Bengal. lb.	Madras. lb.
1934-5	1,095,369	192,271
1935-6	1,329,302	204,206
1936-7	1,452,311	307,895

In Madras the local supplies of good quality factory bark from private sources are stated to be practically exhausted. This means that during the next few years the output of bark from the Government plantations will have to be doubled in order to meet factory requirements, and considerable extension of the plantations will be necessary if this output is to be maintained.

The botanical source of the bark collected on the Madras plantations is not indicated in the official reports, but the bulk of the trees being raised in the nurseries consists of " *C. robusta* ". Most of the Bengal bark is obtained from *ledgeriana* with small quantities of *succirubra*, *officinalis* and hybrids.

The quantities of quinine sulphate made in the Government factories are shown below :—

	Bengal. lb.	Madras. lb.
1934-5	56,561	17,414
1935-6	51,026	9,760
1936-7	57,313	17,130

In both factories there is also a large production of " cinchona febrifuge " and smaller amounts of other cinchona salts and of totaquina.

There is a small export of cinchona bark from India, but this consists mainly, if not entirely, of " druggist's " bark. The quantity shipped during 1937-38 is given as 28,222 lb.

THE WORLD'S CINCHONA BARK INDUSTRY—II, THE PRESENT POSITION OF THE PRODUCTION OF CINCHONA BARK AND QUININE IN EMPIRE COUNTRIES[1] *

COUNTRIES within the Empire, other than India, where the prospects of cinchona cultivation seem to be promising are Tanganyika, the Cameroons under British Mandate and Malaya. A summary of the position in these and in other Empire countries where the tree has been introduced is given in the following paragraphs. In addition it may be mentioned that at one time cinchona bark was produced in Mauritius, Fiji, and Jamaica, but the fall in price of quinine in the eighties killed the industry in these countries. The fact, however, that cinchona apparently succeeded there may be worth bearing in mind when considering possible countries for its cultivation. The climatic conditions in parts of British Guiana have also been regarded as suitable for the tree, but economic considerations would probably prevent the establishment of commercial cultivation in that region at the present time.

TANGANYIKA

In this Territory the conditions obtaining in the Usambara district appear to be particularly suitable for cinchona. Plantations were made there by the Germans 30 to 35 years ago on Bomolo Hill at what is now the East African Agricultural Research Station. The kinds planted include *C. ledgeriana*, *C. succirubra*, *C. robusta* and a hybrid (*C. ledgeriana X C. succirubra*). Small shipments of bark were sent to Germany in 1909 and 1912, and during the War the plantations were able to supply all the quinine needed by the German troops in East Africa and some was shipped also to Germany.

In 1918 samples of bark collected from the four types of tree at Amani were sent to the Imperial Institute for examination. That from the hybrid tree proved to be of specially good quality, giving a yield of 11·21 per cent. of quinine sulphate, showing it to be fully equal to the finest Ledger bark from Java.

Small consignments were subsequently sent to this country for sale and realized satisfactory prices.

In addition to these German plantations an area of 5½ acres was planted on the Drachenberg Plantation in the early twenties with Ledger and hybrid seedlings.

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[1] The position in India was dealt with in the previous part of this article.

* Extract from Bulletin of the Imperial Institute, Vol. XXXVII., No. 2. (April-June, 1939.)

A full account of the history of cinchona at Amani, with a discussion as to the quality and yield of the bark from the different types of tree, will be found in an article by Dr. R. R. Le G. Worsley, published in this Bulletin, 1935, **33,** 14–31.

Lately further development has taken place at Amani and the 38·4 acres under cinchona at Kwamkoro estate were to be increased to 100 acres during 1938. It was proposed that this land should be planted with *C. ledgeriana* as far as seed is available and the remaining area with *C. succirubra* and a hybrid (*C. ledgeriana X C. succirubra*). It is hoped by this means to obtain still further evidence as to the commercial prospects of the crop in this region.

Cinchona is also to be found on certain private estates in Usambara. At Ngamba estate, E. Usambara, there are about 75 acres, and at Balangai estate, W. Usambara, about 50 acres. Both these areas were planted by the Germans and harvesting of the bark has taken place fairly regularly. Cinchona is also grown on Mazumbi estate and at Lushoto.

CAMEROONS UNDER BRITISH MANDATE

Cinchona plots were started by the Germans over 30 years ago on the Cameroon Mountain with seeds and seedlings from good-yielding Java trees. In 1924 the species then present, as determined by Kew, were *C.* near *micrantha*, *C. ledgeriana*, *C. succirubra* and *C. calisaya*. Four samples of bark collected from different plots, which were sent to the Imperial Institute for examination in 1918, proved to be of satisfactory quality for the manufacture of quinine, yielding from 6·7 to 8·2 per cent. of quinine sulphate.

Further trials have since been made by the Department of Agriculture. Seed of *C. ledgeriana* and *C. succirubra* from Java was sown by the Department of Agriculture in 1927 at the Botanic Gardens, Victoria, and the seedlings were planted out in 1929. The Ledger plants are reported not to have done so well as the *succirubra*, and it may be found necessary to graft that species on the latter under the conditions obtaining in the Cameroons. Further evidence seems desirable, however, on this point, as the original Ledger plants are now probably over-mature and those planted in 1929 were put out in an open type of country without the support of forest which is so necessary to the successful growth of cinchona.

It is considered that there are large areas on the Cameroon Mountain which should be suitable for the cultivation of cinchona for totaquina production, but in spite of earlier results it seems doubtful whether satisfactory yields of quinine can be obtained in this region. In view of this and of the unconvincing results of trials with Indian-made totaquina carried out by the medical authorities in Nigeria, it is proposed to discontinue the experimental cultivation of cinchona in the Cameroons area.

KENYA

There is at present no direct evidence as to the suitability of Kenya for cinchona cultivation, but there may be areas in the Highlands where the tree will succeed. The question has been taken up by the Department of Agriculture

and seedlings of *C. ledgeriana* and *C. succirubra* are being raised in Government nurseries for issue to planters in the Sotik and Kericho areas for trial and possibly also to natives elsewhere in humid areas.

New experimental plantings of Indian *ledgeriana* seed, obtained through Amani, have recently been started in the Nandi district and at Kakamega under the supervision of officers of the Agricultural Department in collaboration with the Forestry Department. The nurseries established at Sotik and Meru have proved too cold and exposed for rearing the young plants and have accordingly been given up.

UGANDA

Cinchona is also the subject of trial in Uganda. A small plantation of C. *ledgeriana* was started by the Forest Department at their Arboretum at Entebbe in 1921. The growth was very satisfactory and in 1926 the bark was stripped from some of the trees. A sample of this bark examined at the Imperial Institute in 1927 gave a yield of 5·05 per cent. of quinine sulphate, which is quite satisfactory for five-year-old bark. More recent analyses are understood to have given a higher quinine content.

There are also experimental plantations of *ledgeriana* hybrids at various other places in Uganda at elevations ranging from 3,800 to 5,500 ft. A sample of hybrid bark grown at Bukalasa, also examined at the Imperial Institute in 1927, furnished 3·72 per cent. of quinine sulphate.

It may be mentioned that reports on the Uganda barks were published in this BULLETIN, 1928, **26**, 17, but at that time the exact botanical source of the material was not known and the Ledger bark was erroneously described as being derived from *C. succirubra* and the hybrid bark as *C.robusta* (?)

NYASALAND

Cinchona officinalis was grown at Chiringa, near Zomba, early in this century, but the area was planted up with Ceara rubber in 1907, and subsequently abandoned. In clearing the land in 1928 it was found that, in spite of neglect and over-crowding with other vegetation, some of the trees were still alive, which suggests that the conditions there are not unfavourable to cinchona. No development, however, seems to have taken place in this country.

NORTHERN RHODESIA

A plantation of about 1,000 trees of cinchona is stated to have been established on Hill Wood Farm, Mwinilunga, in 1929. The trees apprently grew well, as some were reported later to be seeding, but no further information as to their progress or as to the species is available.

BURMA

As a result of recommendations made by Colonel Gage in 1918, after his survey of the possibilities of development in India's production of quinine, plantations were started in the Tavoy District of Lower Burma, but in 1921 and 1922, these were practically destroyed by the heavy rains, and cultivation was transferred to the Mergui District. The plantations consisted mainly of *C. ledgeriana* as it was found at an early stage that *succirubra* did not thrive under Burma conditions.

For a few years the Mergui plantations made rapid progress and the outlook seemed promising, but it later became apparent that the site was by no means ideal for cinchona cultivation and that yields comparable with those obtained in Java could never be expected. The difficulty of bringing the plants through the dry season from November to February, coupled with the damage done by the heavy rains in the monsoon presented a serious problem. Experimental cultivation in Upper Burma was advocated, but this plan never materialized.

From 1931–32 onwards there was no further extension of development of these plantations, operations being restricted to maintaining the existing areas in good condition. Production of bark was to be gradually reduced in accordance with the change in the Government policy.

With the transference of the Mergui reserve to the Government of Burma in 1937, the plantations were closed down as the Burma authorities had no wish to continue operations. All mature bark was stripped off and sent to the Mungpoo factory, Bengal.

The quantity of bark handled in the years 1930 31·32 is given below in comparison with 1934–35–36 after the restriction scheme :—

	lb.
1930–31	131,533
1931–32	177,061
1934–35	64,429
1935–36	81,772

CEYLON

Cinchona cultivation in Ceylon was started in about 1860 and by 1875 the exports of the bark, largely obtained from *C. succirubra*, already amounted to nearly 19,000 lb. annually. The ruin of the coffee industry by leaf disease in 1880, resulted in a further increase in cinchona cultivation and by 1887 Ceylon had become the most important producing country in the world, exporting in that year over 13 million lb. of bark. Over-production followed, with a consequent fall in price of the bark, and cinchona cultivation was practically abandoned in favour of tea.

During recent years, however, the industry has to some extent been revived, but the original *C. succirubra* trees, many of which remain scattered about the plantations, yield bark with a low content of quinine. In 1927 the Department of Agriculture attempted to reintroduce *C. ledgeriana* but the trial proved a failure. Experiments are now being carried on with grafting and with the selection of high-yielding strains for scions. Hybrids are also being cultivated experimentally and will be sampled when old enough. On the whole there seems little prospect of successfully developing areas of *C. ledgeriana* in Ceylon.

There is a small export of *succirubra* bark, the figures for the last three years being as follows : 1936, 140,448 lb. ; 1937, 170,128 lb. ; 1938, 155,904 lb.

MALAYA

The first attempt to introduce cinchona into Malaya appears to have been made in 1878, but it was not long before the great fall in the price of quinine occurred and interest in the crop in the Straits then ceased. In 1915 further introductions of *C. ledgeriana* and *C. succirubra* took place, but in most cases

the sites chosen for the plots did not meet the exacting requirements of the tree. Since then trials have been made in the Cameron Highlands with more promising results. Seed obtained from Java was sown at the end of 1926, and in the following year the first seedlings were planted out. Further sowings followed in 1927 and by the beginning of 1929, approximately 2½ acres each of *C. ledgeriana* and *C. succirubra* were planted out on jungle land which had been completely cleared, with an additional acre of each species in thinned out jungle still providing some shade. Three-year-old bark examined in 1930 gave the following satisfactory figures for alkaloid content, but was at the same time remarkably thin :—

	C. ledgeriana Per cent.	*C. succirubra* Per cent.
Total alkaloids ..	9·40 ..	7·31
Quinine sulphate ..	10·53 ..	2·51

Subsequent analyses made in 1936, showed that although the figure for total alkaloids in the Ledger bark was practically the same, the content of quinine had fallen off. The average figure obtained, however, was still better than that for Indian bark, and in isolated trees the quinine content sometimes exceeded that normally found in Java bark.

In order to determine the most suitable site and type of plant a new series of experiments was commenced in 1936. Five plots of one acre each are being established in different parts of the Highlands and in each case *C. succirubra*, *C. ledgeriana* (both on its own roots and grafted on *C. succirubra*) and *succirubra* × *ledgeriana* hybrid are being tried. During 1937 some thousands of plants of *C. ledgeriana* and *C. succirubra* were grown from seed for trials and transplanted to nursery beds, and in addition a number of self-sown hybrid seedlings were collected for nursery cultivation.

Although the soils in the Cameron Highlands are friable and the rainfall is adequate for cinchona and is evenly distributed, much of the land is on steep slopes and for plantations to suceed it will be necessary to select sites as free as possible from the dangers of erosion. Many of the conditions in this region are decidedly encouraging, but it is clear that much more experimental work remains to be done before the possibilities of large-scale planting can be definitely decided.

ST. HELENA

The introduction of cinchona to St. Helena dates from 1868. Seeds of *C. succirubra* and *C. officinalis* were sown in this year and by the end of 1869 a small plantation had been started in an area of partially cleared forest at about 2,000 ft. Although the trees made good growth the plantation was soon abandoned. It was stated in 1917 that the trees were then still in healthy condition after years of neglect and had reproduced naturally from seed. Samples of bark from both species were examined at the Imperial Institute in 1917 and gave yields of alkaloid which were higher than the average for *C. succirubra* and *C. officinalis* (see this BULLETIN, 1918, **16**, 383.)

NEW GUINEA

Although in Central New Guinea the soil, elevation, climate and rainfall conditions resemble very closely those of Java, the introduction of cinchona into this territory is only very recent. Seedlings have been reared successfully in the Ramu Valley and it was stated early last year that the Government Experimental Station had many hundreds of well-grown plants suitable for distribution. They are as yet too young for determinations of the quinine content.

THE POSITION IN FOREIGN COUNTRIES[1]

Apart from the Netherlands East Indies cinchona has been introduced into a large number of foreign countries, but in most of these cultivation is still in the experimental stage. In the French Colonies trials are being carried out in Reunion, Madagascar, the French Cameroons and Indo-China (where nearly 1¾ tons of quinine sulphate were produced in 1938), and much work is being done in the Belgian Congo. There is a small export of bark from the Island of San Thome. In the Far East plantations have been started in Formosa, whence the Japanese in time hope to obtain all their quinine requirements, and in the Philippine Islands, where totaquina has been prepared from locally grown bark. Attempts are also being made to establish the tree on plantation lines in Central America, especially in Guatemala. Other countries where trials are being made include Eritrea, Spain and the sub-tropical parts of the U. S. S. R. An outline of the developments in these countries and of the present position with regard to cinchona production is given in the ensuing paragraphs.

BELGIAN CONGO

Although cinchona is said to have been grown in the Belgian Congo before 1890 extensive trials were not undertaken in the colony until 1901. Since that date there have been many introductions both of seeds and of young plants reared at the Jardin Colonial of Laeken in Belgium. It has been found that the plains of the Congo basin are too low-lying for satisfactory growth of cinchona, but promising results have been obtained from some of the hill stations on the eastern borders of the colony. In the Kivu district the Government experimental stations at Mulungu and Tshibinda, which are under the control of the Institut National pour l'Etude Agronomique du Congo Belge (INEAC), have considerable plantations of *ledgeriana*, *succirubra* and *robusta* at altitudes of 5,000 to 6,500 ft. These trees, which include some derived from seed of high-yielding strains obtained from Java, are giving satisfactory yields, and indeed some of the bark analyses show remarkably high contents of both quinine and other alkaloids.

In addition to the Government experiment stations, where selection work is being carired out, mention may be made of the Synkinac (Synquinak) Society's plantation at Kalonge, also in the Kivu district, which comprises about 80,000 trees, and that of the Fataki Mission in the Ituri district further north with over 50,000 plants. Further extension of the area under cinchona is proposed, but the aim of all these enterprises is to supply quinine for consumption in the Congo rather than for export.

[1] The position in the Netherlands East Indies was dealt with in the previous part of this article.

FRENCH INDO-CHINA

Attempts to establish cinchona in French Indo-China have constantly met with such difficulties that although the earliest introduction dates from 1869 cultivation has still hardly progressed beyond the experimental stage.

The chief problems lie in the comparative scarcity of suitable soil and the lack of available planting space at sufficiently high altitudes, for under the conditions prevailing in the colony it does not appear possible to grow cinchona below about 3,500 ft. without heavy losses from collar rot disease.

The more recent trials commenced in 1917, with the opening by the Institut Pasteur of the Hon-Ba experimental station, which is situated on the Lang-Bian plateau in southern Annam at an altitude of about 4,900 ft. The soil in this locality is of granitic origin, rather shallow and poor in humus, and the young cinchona plants, some of which were grown from seed (*ledgeriana* and *succirubra*) and some from young grafts obtained from Java, did not survive long.

Further plantings in southern Annam were made by the same Institute in 1923 and 1924 at Dran (about 4,900 ft.) and Djiring (3,200 ft.) in the Haut Donnai. These stations have a soil of basaltic origin, somewhat richer than that of Hon-Ba, but the climatic conditions are not very favourable, there being a dry season of about five months. Results were at first encouraging, but after three or four years the plants became unhealthy and weakened by disease and precocious flowering. Plants were reared from the seed of these trees, however, at Petit Langbian (5,200 ft.), where they made good growth and gave yields of from 8 to 12 per cent. of quinine sulphate at the age of seven years. Unfortunately there is no land available for extensive cultivation at this altitude and it has been necessary to concentrate attention on lower stations. The chief of these is at Diom (3,600 ft.) not far from Dran, which was planted with *ledgeriana* in 1932. Here the Institut Pasteur hope eventually to reach a maximum annual production of 3,000 kilos of quinine sulphate for a period of ten years. The actual yields from loppings and thinnings in 1937 and 1938 were as follows :—

		1937.	1938.
Bark	kilos	20,650	21,100
Quinine sulphate	kilos	1,434	1,793
Quinine sulphate	per cent.	6·92	8·50

Cinchona has also been planted at experimental stations of the Institut des Recherchés Agronomiques de l'Indochine. These are situated at Lang-hanh (3,300 ft.) and Blao (2,800 ft.) on the Haut Donnai plateau and at Paksong (3,600 ft.) further north on the Bolovens plateau.

CAMEROONS UNDER FRENCH MANDATE

The moist climate and volcanic soils of the mountains of the Cameroons seem to present conditions admirably suited to the growth of cinchona and very promising results have been obtained from trials carried out in the territory under French mandate.

Since 1922 numerous consignments of seed have been sent to the territory for planting at the Cinchona Station at Dschang, which is situated at an altitude of about 4,900 ft. Possibly owing to the poor quality of the seed received, these efforts met with no success during the first six years and it was not until 1928 that healthy seedlings were reared. Since then progress has been more satisfactory, and by 1937, there were a few dozen plants of *ledgeriana* making slow development and about 8,000 vigorous *succirubra* plants, the older trees being already up to about 25 ft. high. Analyses of the bark show a quinine sulphate content of 5 to 9 per cent. in the *ledgeriana* but only 1 per cent. in the *succirubra*, which, however, gave satisfactory yields (up to about 8 or 9 per cent.) of total alkaloids. Grafts of *ledgeriana* on *succirubra* stocks were started in 1935 and 1936, but at the time of writing the results of these experiments were not available.

The chief aim of the work, however, seems to be directed towards the growth of *succirubra* for totaquina production. An abundant supply of seed is now available from the plants introduced in the early stages of the work and 40,000 new *succirubra* plants have been put out since 1934 at various stations, some at considerably lower altitudes than Dschang, as, for example, Yaounde (2,600 ft.), on the central plateau of the Cameroons. These new plantations are reported to be making very satisfactory progress.

MADAGASCAR

Early attempts to establish cinchona in Madagascar were made from about 1896 to 1902 with the introduction of seed from Reunion and a number of young *ledgeriana* plants and grafts obtained from Java. Many of the plants died prematurely, but the experiments were abandoned before any decisive conclusions were reached. In 1914 analyses were made of the bark of some of the trees which still survived, but the yield of alkaloids was very poor.

Fresh trials with seed of *ledgeriana* and *succirubra* obtained from Java were started in 1928 at a station in the Forest of Ambre situated at about 3,300 ft. Conditions appeared fairly well suited to cinchona, and the trees made healthy growth, but analyses made in 1933 showed a very poor yield of quinine. The total alkaloid content was in some cases fairly satisfactory, but it can hardly be said that Madagascar appears promising as a future source.

REUNION

Early cultivation trials with cinchona in Reunion were carried out on a considerable scale. The first successful introduction was in 1886, and by 1894 there were said to be as many as 80,000 cinchona plants of various species on the Island. Most of these were *succirubra*, which was found to grow well, particularly between the altitudes of about 1,600 and 3,300 ft. The yields of alkaloid obtained were unsatisfactory, however, and further trees reared from local seed, some of which was doubtless the result of free hybridisation, gave disappointing results. Interest in cinchona culture gradually waned, and many plantations were totally abandoned.

Since 1918 cultivation has been resumed and in 1935 from 1,500 to 2,000 trees were being exploited annually by the Grency Government Forestry Service. The whole of this supply of bark is being purchased by the Government Medical Service.

ERITREA

Cultivation of cinchona in Eritrea is still at an experimental stage. Plants of *ledgeriana* and *succirubra* have been reared from seed introduced from Java in 1926, but so far the results indicate that the local conditions are more suitable to *succirubra* than *ledgeriana*.

SPAIN

It was reported in 1933 that cultural experiments with cinchona were to be made in Spain and the Canary Islands under the auspices of the National Institute of Foresty Research. Seed was obtained from Java, but there appears to be no further information regarding these trials.

PORTUGUESE COLONIES

Cinchona was early introduced into the Portuguese colonies of San Thome Principe, the Cape Verde Islands and Madeira, but although the trees appear to have grown reasonably well in the Cape Verde Islands it is only in San Thome and Principe that cultivation was developed. The Island of Timor has also been considered as a possible producer of cinchona, but there have been no serious attempts to introduce the crop there.

The first plants in San Thome appear to have been reared from seed received in 1869, but most of the later plantations were derived from seeds and young plants sent from Lisbon from 1873 onwards. These originated from various sources, including Java and British India.

Cultivation developed steadily and by 1891 the annual production of bark in San Thome and Principe amounted to nearly 110,000 lb. These Islands have continued to produce cinchona, but the industry has suffered from the vicissitudes of the quinine market and in recent years there has been a considerable decrease in the output. Interest in cinchona is now reviving, however, owing to the unfavourable state of the market for cocoa, which is the principal export crop of the Islands.

U. S. S. R.

Experimental work is being carried on in Transcaucasia with the object of developing a new method of cinchona production in which the entire plants are used for alkaloid extraction at the age of only one or two years. In this way it is hoped to overcome the difficulty of the rigorous winters of this region.

From the results of trials in which young plants were reported to contain about 1·4 per cent. of total alkaloids, it has been estimated that yields of 31 lb. of alkaloids per acre may be expected. There is no evidence so far, however, that the preparation of the alkaloids from these young plants will prove economical on a commercial scale. It is reported that large experimental plantations of *succirubra* have been laid out in the warmer regions of Georgia, but the results of this work are not yet to hand.

PHILIPPINE ISLANDS

In the Philippines cinchona has been grown by the Forestry Department since 1927 for the preparation of totaquina for domestic consumption. Prior to this date there were a number of fruitless attempts to introduce the crop, but by the beginning of 1937 plantations occupying about 34 acres had been established at Bukidnon at an average altitude of 2,500 ft., with some 39,000 trees over two years old and 110,000 seedlings. A second area at an altitude of about 3,500 to 4,500 ft. was planted more recently and further extension is now planned. The trees consist of *ledgeriana*, *succirubra* and "hybrida" originating from Java seed. The yields of alkaloid have not been very high, but up to the beginning of 1937 a total of some 10 metric tons of bark had been harvested.

Lately there has been serious trouble in the plantations occasioned by disease which is thought to be due in part to unfavourable soil conditions. Planting at higher altitudes has been suggested as the plants appear to be more vigorous under such conditions and should therefore be less susceptible.

FORMOSA

Cinchona is grown in Formosa chiefly by commercial firms operating concessions on government lands. The plant was introduced from Java in 1919, but it is only during the last few years that the cultivation has received much attention. A greatly increased production is now planned and it is hoped that eventually Formosa will be able to supply all Japan's requirements of quinine.

The species introduced are *ledgeriana, succirubra* and "hybrida"; they appear to grow reasonably well under Formosan conditions at altitudes of between 2,000 and 3,000 ft., but have not so far given particularly high yields of quinine. No information is available as to the actual production in Formosa.

SOUTH AMERICAN COUNTRIES

The eastern slopes of the Andes form the natural home of the cinchona tree, but there has been so much promiscuous destruction of the plants through wasteful methods of collecting the bark that in many regions the trees only survive in inaccessible forests. There appears to be no systematic cultivation of cinchona, and supplies of bark gathered from trees growing wild in the forests are gradually diminishing. Certain quantities are still exported from Equador (*succirubra*) and Peru.

Proposals to cultivate the trees have not materialized owing to lack of funds and difficulties of transport, but there has recently been established in Bolivia a government plant for the preparation of quinine from local bark. It is reported that the plant will produce considerable quantities of refined quinine for export and in order to ensure an adequate supply of raw material it is proposed to prohibit any further export of the bark.

It was reported in April 1939, that 1,000 seedling cinchona trees raised in the experimental gardens of the United States Department of Agriculture at Washington have been sent to Brazil for trial planting. The seedlings are stated to have stood the journey well and have survived transplanting. The results of this experiment will be watched with great interest.

GUATEMALA

Interest in cinchona cultivation has been revived during the last few years with a view to commercial production. Before extensive planting it is intended to make a careful choice of the localities most suitable for the growth of the crop, and to this end a number of small experimental plots are to be established under varying conditions of climate, altitude and soil. Seed is to be provided from old trees which originate from former abandoned plantations and have become naturalized in the country. A quinine content in the bark of more than 5 per cent. is looked for in trees to be used as a source of seed.

THE RICE CROP IN BURMA

(An extract from the *Agricultural Survey* No. 17 of 1932 (Reprinted—1939) of the Department of Agriculture, Burma.)

Costs of Cultivation.—It is difficult to obtain accurate information about the costs of cultivation. Cultivators keep no accounts and some work their holdings themselves with their own cattle and the help of their families, while others have to engage labourers and hire cattle or buffaloes.

In the tables below the costs, as far as they can be estimated, are shown for a holding of 20–25 acres in Lower Burma, assuming that the tenant cultivator owns one pair of bullocks only and that he has a wife, son or daughter who can help him throughout the season. He will have to engage one labourer and hire one pair of bullocks, and it is assumed that the outturn is 30 baskets to the acre. The present market price of paddy is Rs. 100 per 100 baskets (4,600 lbs.) *

COSTS OF CULTIVATION OF 25 ACRES OF PADDY LAND ON A CULTIVATOR'S HOLDING, ASSUMING THAT HE OWNS A PAIR OF BULLOCKS, HAS A WIFE AND SON OR DAUGHTER TO HELP HIM THROUGHOUT THE SEASON.

	Rs.	A.
(I.) *During the Transplanting and Cultivation Season*—		
(*a*) One hired labourer to cultivate, transport *pyos*, *kazin* repairs, &c., 40 baskets for five months during the rains calculated at Rs. 100 per 100 baskets	40	0
(*b*) Cost of feeding one labourer for five months at Rs. 6 per month	30	0
(*c*) Cost of seed paddy ; 25 baskets at Rs. 100 per 100 baskets ..	25	0
(*d*) Cost of *pyo*-plucking about Rs. 2 per acre (he or his son also helps)	50	0
(*e*) Cost of transplanting at Rs. 3 per acre (his wife or daughter helps)	75	0
(*f*) Cost of hiring one pair of bullocks for cultivation season ; 50 baskets at Rs. 100 per 100 baskets	50	0
	270	0
(II.) *During the Reaping Season*—		
(*a*) One hired labourer for carting, threshing, and winnowing ; 20 baskets at Rs. 100 per 100 baskets	20	0
(*b*) Cost of hiring one pair of bullocks for threshing only ; 10 baskets at Rs. 100 per 100 baskets	10	0
(*c*) Cost of feeding one labourer for one month at Rs. 6 per month	6	0
(*d*) Reaping 25 acres at about Rs. 3 per acre (he or his son also helps)	75	0
Total cost of Cultivation ..	381	0
Total cost of cultivation per acre ..	15	4

* Since the costs were estimated there has been a further decline in prices to about Rs. 65 in 1933, due to world wide depression, but approximate costs at any given time may be estimated by substituting current prices for those shown in the statement.

	Rs.	A.
(III.) Rent on 25 acres at 10 baskets per acre ; 250 baskets at Rs. 100 per 100 baskets	250	0
(IV.) Outturn of crop 25 acres at 30 baskets per acre ; 750 baskets at Rs. 100 per 100 baskets	750	0
Surplus ..	119	0

If the tenant cultivator owns his own cattle his surplus will be Rs. 179. If he owns his land and has his own plough cattle he will have to pay land revenue at about Rs. 3 per acre instead of rent. His surplus will therefore be Rs. 179 plus (Rs. 250—Rs. 275), which is Rs. 354.

CULTIVATION COSTS.

Ploughing.—One man and one pair of bullocks will plough one-third of an acre in one morning of six hours.

Harrowing.—Generally given eight turns on the field to get a good tilth ; one man and one pair of bullocks will harrow half an acre in one morning, giving eight turns.

Settun.—Generally four turns are given on the field ; one man and one pair of bullocks will finish one acre in one morning doing four turns.

Plucking pyos.—One man will pluck 25–30 *lets* of *pyos* per day ; rate Rs. 4 per 100 lets.

Transplanting.— Six women will transplant an acre per day ; rate annas 10 per woman per day.

Reaping.—One man will reap one-fourth to one-third acre per day ; rate Rs. 3 and annas 8 per acre.

MEETINGS, CONFERENCES, &c.

COCONUT RESEARCH SCHEME

BOARD OF MANAGEMENT

MINUTES OF THE FORTY-EIGHTH MEETING OF THE BOARD OF MANAGEMENT, COCONUT RESEARCH SCHEME, HELD IN ROOM NO. 202, NEW SECRETARIAT, COLOMBO, ON WEDNESDAY, OCTOBER 11, 1939, AT 10 A.M.

PRESENT.

Mr. E. Rodrigo, C.C.S., Acting Director of Agriculture (in the Chair); Mr. C. H. Collins, C.C.S. (Treasury Representative); Mr. O. B. M. Cheyne; Mr. James P. Fernando; Mr. D. D. Karunaratne, J.P.; Mr. G. Pandittesekera, J.P., U.P.M.; Mr. L. J. M. Pieris, M.B.E., B.A.

Dr. R. Child, Director of Research, acted as Secretary.

Apologies for absence were received from Messrs. A. R. Ekanayake and E. R. Tambimuttu, M.S.C.

MINUTES.

The minutes of the previous meeting held on Friday, September 15, 1939, which had been circulated to members, were confirmed.

It is here recorded that the following members visited Bandirippuwa and Ratmalagara estates on Monday, October 2, 1939, to inspect work in progress :— Messrs. O. B. M. Cheyne, James P. Fernando, D. D. Karunaratne, G. Pandittte-sekera and H. W. Pieris.

FINANCE.

Estimates, 1940.—The attached Estimates for 1940 were approved.

Depreciation.—It was decided to provide provisionally for Depreciation, 1940, at half the usual rate, with the exception of Gas Plant and Accumulators, which are to remain at 10 per cent. and 12½ per cent. respectively. The position is to be reviewed in October, 1940.

Sale of Publications.—On the suggestion of the Deputy Financial Secretary, it was decided that the position regarding sale of publications should be reviewed, with a view to increasing revenue from this source.

Statement of Receipts and Payments.—The Statement of Receipts and Payments for the Quarter ended September 30, 1939, was tabled and approved.

PROGRAMME OF RESEARCH.

The Programme was discussed item by item and the attached draft finally approved. With reference to the question of acetic acid from coconut shells, the Chairman reported progress. The Board decided that the Chairman should continue to have authority to proceed with this matter and to incur extra expenditure up to Rs. 1,000 without immediate reference to the Board.

Consumption research.—The Chairman referred to a letter received from the Low-Country Products Association following the discussion of that body on the Draft Memoranda on the Future of the Scheme. In it they had again

asked whether more stress could be had on consumption research, and suggested certain items to be undertaken. The Chairman said that some of these had been embodied, and it was thought that, without increase of staff, it was not possible to add to the programme.

The Director of Research said that efforts were being made to reduce his routine office work. In particular he was proposing to re-organize the management of the Estates on company lines, so that the main office work would merely be that of an agent.

The Board approved and authorized the Chairman to deal with any modification of financial arrangements which such re-organization might entail.

The Director of Research was also asked to report what information was available on each of the items, suggested by the L. C. P. A.

APPOINTMENT OF VISITING AGENT.

In connection with the suggestion made by the Director of Research at the previous meeting and papers subsequently circulated, it was decided that if a Visiting Agent were appointed, he should be asked to pay two visits a year to each estate ; and it should be understood that the Visiting Agent had no concern with experiments in progress but only with the general working of the estates.

MISCELLANEOUS.

Daily Paid Non-Ceylonese Labour.—In accordance with the Board's instructions at the previous meeting, the Chairman reported the number and the period of service of each of the non-Ceylonese labourers employed at Bandirippuwa and Ratmalagara estates.

After some discussion, it was decided that, in view of the comparatively small number of non-Ceylonese labourers, it was not necessary to discontinue their services, but that no daily-paid non-Ceylonese labourers are to be taken on in future.

Training of Students.—The Chairman referred to the discussion on training of students which took place at the 45th meeting held on April 19, 1939 ; he reported that he had communicated to the Hon. the Minister for Agriculture and Lands the Board's views as then expressed. The Minister had replied that he did not think that a satisfactory scheme to give a training on University lines could be worked out, but wished a scheme to be prepared, if possible, to give a student who wanted to do practical agriculture, an opportunity to learn the science and practice of coconut planting.

After further discussion, the Board decided that they accepted the view expressed by the Director of Research that there was little prospect of framing a scheme for such training at Bandirippuwa estate at present ; but that as Ratmalagara estate was developed it might be possible to consider the question later. It was resolved that a reply should be sent to the Hon. the Minister on these lines.

CORRESPONDENCE.

Future of the Coconut Research Scheme.—The Chairman reported that, following the Board's decision at the previous meeting, he had addressed a

letter to the Hon. the Minister for Agriculture and Lands asking that Government be approached with a request that, as a temporary measure pending a review of the whole situation under the stable conditions of peace, the present annual grant of Rs. 30,000 be continued for one year after the termination of the present hostilities. Further progress would be reported in due course.

Collaboration Committee, Food Control and Production.—The Chairman said that the Director of Research had received a letter from the Asssistant Government Agent, Puttalam, asking him to attend a public meeting for the purpose of considering the formation of a local committee in connection with the food products question.

The Board gave a general instruction that the Scheme could assist the local authorities whenever possible provided that the work of the Scheme was not interrupted.

Mr. Menon's Work.—The Chairman reported that a communication had been received from the Chairman, Ceylon Coconut Board, asking whether the Board of Management, Coconut Research Scheme, would agree to Mr. Menon carrying out work at Bandirippuwa on the manufacture of artificial leather from immature nuts.

The Board of Management, Coconut Research Scheme had previously agreed that it desired to claim no rights in this patent of Mr. Menon's.

The Board agreed that they had no objection to Mr. Menon pursuing this work at Bandirippuwa, provided that it was regarded as subsidiary to his main work on paper.

The meeting adjourned at 12.35 P.M.

Circulation Paper No. 381.

COCONUT RESEARCH SCHEME.

Estimates of Income and Expenditure for 1940.

(*Approved by the Board of Management on October 11, 1939.*)

SUMMARY.

	Rs.	Rs.
Revised Estimate of Revenue in 1939	89,944	
Revised Estimate of Expenditure in 1939	104,515	
Deficit		14,571
Estimated Income in 1940	88,672	
Estimated Expenditure in 1940	95,228	6,556
Deficit (1939-1940)		21,127
Surplus on December 31, 1938		53,853
		32,726
Transfer to Capital Account		18,450
Estimated Surplus on December 31, 1940		14,276

Capital Account.

	Rs.	Rs.
Transfer from Cash Balance	18,450	
Revised Estimate of Expenditure in 1939		9,450
Estimated Expenditure in 1940		9,000
	18,450	18,450

Bandirippuwa estate,
Lunuwila,
October 23, 1939.

REGINALD CHILD,
Director of Research.

Estimate of Income for the year 1940.

		Income in 1938. Rs.	Estimate for 1939. Rs.	Revised Estimate for 1939. Rs.	Estimate for 1940. Rs.
1.	Grant-in-aid	30,000	30,000	30,000	30,000
2.	Cess Collections	58,690	40,000	40,000	40,000
3.	Interest	2,792	2,900	3,548	3,825
4.	Income from Bandirippuwa estate—				
	(a) Estate area	9,923	8,250	8,250	6,750
	(b) Research area	3,990	3,750	3,750	3,250
5.	Sale of planting material from co-operating estates	—	—	—	1,000
6.	Income from Ratmalagara estate	3,057	3,000	3,300	3,000
7.	Charges to Staff for Electricity	978	984	874	834
8.	Sale of Publications	130	—	25	—
9.	Charges for Telephone (No. 2 Senior staff Bungalow)	40	40	27	13
10.	Sundry Receipts	264	—	170	—
		109,864	88,924	89,944	88,672

Estimate of Expenditure for the year 1940.

		Expenditure in 1938. Rs.	Estimate for 1939. Rs.	Revised Estimated Requirements for 1939. Rs.	Estimate for 1940. Rs.
A.	*Capital Account*:				
1	(a) Purchase of Ratmalagara estate	73,138	—	—	—
	(b) New Clearings	497	1,000	1,000	1,000
	(c) Fencing	912	1,000	500	—
2	(a) Buildings: New Battery Room, Store, &c.	810	—	—	—
	(b) Extensions to Bungalows	5,072	—	—	—
	(c) Store Room at Ratmalagara estate	1,000	—	—	—
	(d) Circuit Bungalow at Ratmalagara estate	—	8,500* (d) and (e)	5,750	—
	(e) Superintendent's Bungalow at Ratmalagara estate	—		—	6,000
3.	Equipment of Laboratory	1,602	2,000	2,000	2,000
4.	Office Furniture and Equipment	380	500	200	—
5.	Museum	2	—	—	—
6.	Additional Electric Installation	1,155	—	—	—
		84,568	13,000	9,450	9,000

* Provisional vote for 1939.

Estimate of Expenditure for the year 1940.

		Expenditure in 1938. Rs.	Estimate for 1939. Rs.	Revised Estimated Requirements for 1939. Rs.	Estimate for 1940. Rs.
B.	*Personal Emoluments*:				
1.	Director of Research and Technological Chemist	15,137	15,887	15,887	16,350
2.	Geneticist	8,930	9,380	9,208	9,506
3.	Soil Chemist	8,025	8,475	8,475	8,925
4.	Asst. to Technological Chemist	1,255	1,375	1,375	1,495
5.	Asst. to Geneticist	1,690	1,800	1,800	1,800
	Allowance	—	—	200	375
6.	Asst. to Soil Chemist	1,660	1,780	1,780	1,900
7.	Superintendent of estate	2,120	2,220	2,220	2,220
8.	Two Field Assts. (Soil Chemist's Department)	1,371	1,428	1,428	1,548

	Expenditure in 1938.	Estimate for 1939.	Revised Estimated Requirements for 1939.	Estimate for 1940.
	Rs.	Rs.	Rs.	Rs.
9. Two Field Assts. (Geneticist's Department)	546	1,255	1,255	1,375
10. Estate Conductor	376	638	600	638
11. Head Clerk	1,500	1,500	1,500	1,500
12. Two Junior Clerks	1,262	1,382	1,382	1,502
12a 1 Extra Clerk	—	—	164	—
13. Mechanic	1,035	1,080	990	1,080
14. Two Laboratory Attendants	795	660	660	660
15. Office Peon	218	224	224	230
16. Provident Fund Contribution (including interest)	2,732	3,200	3,167	3,600
17. Rent allowance	316	318	590	332
C. *Other Charges :*				
1. Travelling Expenses—Staff	4,734	3,750	4,400	3,000
2. Do. Board Members	313	750	600	700
D. *Office :*				
1. Stationery	747	1,000	1,000	600
2. Postages	646	750	750	750
3. Printing and Advertising	1,585	1,500	1,500	1,000
4. Legal Expenses	250	100	100	100
5. Incidental Expenses	1,035	1,000	1,000	1,000
6. Telephone	460	355	373	329
7. Propaganda	523	750	400	250
8. Entertainment Allowance	93	200	150	100
9. Workmen's Compensation	—	—	78	78
E. *Laboratory :*				
1. Upkeep, Chemicals, Apparatus and Instruments	2,972	2,000	2,350	2,000
2. Scientific books and periodicals	1,855	1,750	2,000	1,000
F. *Buildings :*				
1. Upkeep of Buildings	1,611 965	1,000	1,100	1,000
2. Insurance of Buildings	507	510	507	507
3. Running Expenses of Electric Plant	2,300	2,100	2,100	2,000
G. *Estate Account—Bandirippuwa :*				
1 General Charges	2,178	2,000	2,200	2,000
2. Upkeep	1,193	1,200	900	900
3. Cultivation	1,170	2,500	2,250	2,000
4. Collection	484	600	500	500
G (i). *Estate Account—Ratmalagara :*				
1. General Charges	2,488	1,500	1,650	1,500
2. Upkeep	1,244	1,500	900	1,000
3. Cultivation	466	1,000	1,000	1,000
4. Collection	180	300	200	300
H. *Research Account :*				
1. General	194	200	450	200
2 (a) Genetical work	1,031	1,000	1,000	1,000
(b) Purchase of planting material from co-operating estates	—	—	700	1,000
3. Soil Chemist's work	1,614	3,600	3,600	1,750
I. *Loan :*				
Instalment in repayment of loan of Rs. 50,000	5,000	5,000	5,000	5,000
Interest at 4 per cent.	2,500	1,800	1,800	1,600
J. *Reserve for Depreciation*	14,017	11,280	11,052	6,028
	43,969	103,597	104,515	95,228

PROGRAMME OF EXPERIMENTS OF THE COCONUT RESEARCH SCHEME FOR 1940.

A.—Geneticist's Department.

I.—BANDIRIPPUWA ESTATE.

* (a) *Yield records.*—These will be continued on Geneticist's Blocks A and B and on the selected seed palms.

Objects.—(i.) To ascertain the relation between climate, particularly rainfall, and the physiological activities of palms of high, low and average yielding capacity. (ii.) To isolate high yielders for provision of planting material.

* (b) *Dwarf palms.*—Detailed records on 12 dwarf palms will be continued.

Object.—To study on a small scale the development, the earliness of maturity, period of economic production and yield of the green dwarf palm.

† (c) *Nurseries.*—A uniformity trial with nursery seedlings will be laid down late in 1940 when the Geneticist has returned from study leave.

Object.—To obtain data on the natural variation of seedling growth, which will enable experiments—such as manurial trials—on seedlings to be planned with greater accuracy.

II.—CO-OPERATIVE EXPERIMENTS.

* (a) *Yield records.*—Records on 12 estates (including 5 added in 1939)—containing 852 palms—will be continued, and six more estates (about 300 palms) added.

Object.—To extend the selection of high yielders on private estates for the purpose of supplying good planting material.

* (b) *Experimental Plantations. I. Plantation I.*—Recording work on this will be continued.

II. Recording on this secondary plantation will be continued.

Objects of I and II.—To study the nature of segregation of characters in relation to yield, *e.g.*, of the *unselected* (in plantation I) and the *selected* (in plantation II) of proved high yielding palms.

III.—Matale plantation records will be continued.

Object.—To study the performance of selected seedlings planted on a fairly large scale under private management in the Matale District.

III.—RATMALAGARA ESTATE.

* (a) *Field experiment 1.*—The seedlings now in the nurseries will be planted out in November, 1939, for this 6 × 6 Latin square experiment. Records will continue during 1940.

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* Indicates work which has been in progress, or to which reference has been made in previous programmes or reports.

† Indicates new lines of work, on those which have developed from previous work in modified directions.

Object.—To compare the performance of selected and unselected seedlings from proved high yielders, proved low yielders, and nuts picked at random from estate heaps.

* (*b*) *Field experiment 2.*—An experiment designed to test the relation between yield, planting distance, depth of planting and manurial treatment of seedlings will be laid down in collaboration with the Soil Chemist in 1940.

Object.—As stated.

† (*c*) *Dwarf palms.*—An area of from 8–10 acres will be planted with dwarf palms in 1940.

Object.—As in I (*b*) on a field scale.

B.—Soil Chemist's Department.

I.—Field Experiments.

† (*a*) *Bandirippuwa Estate.* (i.) *NPK Manurial Experiment.*—Yield recording on this experiment will be continued in 1940, the sixth year of the experiment.

Object.—To determine the response of mature coconut palms to the three manurial constituents, Nitrogen, Phosphoric Acid and Potash, at the levels nil, single and double doses of each continued in all possible ways.

(ii.) *Cover crop experiment.*—Records to be continued during 1940.

Object.—To determine the effect on mature coconuts of growing a cover crop and testing it in different ways, with and without fertilizers.

* (*b*) *Ratmalagara Estate.* (i.) *Combined manurial and cultivation experiment.*—Pre-manurial records on this experiment will be kept in 1940.

Object.—As in I (*a*) (i.) with simple manurial treatment, but the addition of cultivation treatments for comparison of this effect and the interaction with manurial treatments.

(ii.) *Manurial experiment on seedlings.*—In collaboration with the Geneticist—see A III (*b*).

† (*c*) (i.) *Manurial experiments on other estates.*—Yield recording on these experiments will be continued in 1940.

* (ii.) *Fodder grass experiment.*—Records on fodder grass harvested and on the yields of the coconut will be kept in 1940.

Object.—The object of this new experiment is to study the effect on mature palms of growing fodder grass beneath them, and of various fertilizer treatments continued with the fodder cultivation.

* Indicates new lines of work, on those which have developed from previous work in modified directions.

† Indicates work which has been in progress or to which reference has been made in previous programmes or reports.

II.—LABORATORY INVESTIGATIONS IN CONNECTION WITH FIELD EXPERIMENTS.

Soil analyses will be done as exigencies permit on samples from the N. P. K. and cover experiments.

Objects.—To study the effect on soil composition and nature of fertilizer treatment and cover crop treatment.

III.—OTHER INVESTIGATIONS.

* (a) *Cattle manure.*—An investigation on cattle manure from the point of view of amount of manure per head from cattle grazed and stall-fed and composition of same. Later, on the basis of this, a manurial experiment comparing cattle manure and other fertilizer treatments.

Objects.—As stated.

* (b) *Soil moisture.*—An experiment to compare the effect of soil moisture of covers, grass, clean weedings, husk mulching and cultivation will be commenced in 1940.

C.—Technological Chemist's Department.

† I.—COPRA.

(a) *Individual variation between palms.*—Routine analyses by a rapid approximate method will be continued on 100 nuts per pick during 1940.

Object.—To ascertain whether there is a significant difference in oil content between nuts from individual palms and thus whether there is any possibility of attempting breeding for high oil content.

† (b) *Grades of copra.*—Examination of samples of No. 2 and No. 3 copra from estates will be continued in 1940.

Object.—To ascertain what are the average characteristics of estates No. 2 and No. 3 copra ; and to compare these with accepted buyers' standards for the grades.

II.—LABORATORY WORK IN CONNECTION WITH OTHER DEPARTMENTS.

* (a) *Phosphoric acid.*—Examination of samples of nut water and kernel for phosphorus compounds from nuts of various ages; at various stages of germination and from different manurial treatments.

Object.—Ultimately to ascertain whether phosphoric acid applications, which do not appear greatly to affect yield, have any effect on the seed nuts from the palms as regards their germination and subsequent growth.

III.—TODDY PRODUCTS.

† (a) *Dwarf Palms.*—Tapping of dwarf palms will be continued.

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* Indicates new lines of work, on those which have developed from previous work in modified directions.

† Indicates work which has been in progress, or to which reference has been made in previous programmes or reports.

Object.—To ascertain the average toddy yield of dwarf palms, its composition and therefore whether dwarf palms are likely to be of economic interest for toddy and its products.

* (*b*) *Fermentation, Preservation of Toddy.*—Continuation of these experiments with other preservatives than those already examined.

Objects.—(i.) To study the course of fermentation, particularly acetification.

(ii.) To determine the minimum quantities of various preservatives required to stop the fermentation of toddy.

(iii.) To investigate the possibility of bottling toddy in a wholesome way.

* (*c*) *Vinegar.*—Examination of further samples of known genuineness and of trade samples will be done in 1940.

Objects.—(i.) To establish reasonable analytical standards to which a genuine coconut toddy vinegar may be expected to conform.

(ii.) To determine as far as possible the extent to which dilute synthetic acetic acid is sold as toddy vinegar.

IV.—Other Products.

(*a*) *Coconut Shell Distillation.*—Extension of this work to the following will be undertaken in 1940 :—

† (i.) Further examination of the crude acetic acid (pyroligneous acid) from shells to see whether further purification is practicable. The Rubber Research Scheme has agreed to examine all samples produced and to report on their suitability for rubber coagulation.

† (ii.) Further examination of shell tar with a view to local production of creosote and of a disinfectant fluid using coconut oil soap.

(iii.) Translation of laboratory work to a commercial scale.

Objects.—As stated.

* (*b*) *Canning Products.*—The technical assistant has received instruction in canning and bottling method and will continue work on canning coconut products such as kernel, coconut milk, &c.

Objects.—Commercialization if possible of edible coconut products.

(*c*) *Advisory work.*—As required.

* Indicates work which has been in progress, or to which reference has been made in previous programmes or reports.

† Indicates new lines of work, on those which have developed from previous work in modified directions.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED OCTOBER 31, 1939

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1939	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Rinderpest	7	..	..	..	..	7
	Anthrax	12	..	10	2	..	..
	Piroplasmosis	6	1	1	5	..	..
	Rabies	2	..	..	..	..	2
	Haemorrhagic Septicaemia	3	..	3	..	..	..
	Blackquarter	1	..	1	..	..	..
Colombo Municipality	Foot-and-mouth disease	33	..	3	29	..	1
	Anthrax	1	..	1	..	..	..
	Rabies	3	1	3	..	..	..
	Piroplasmosis	6	..	1	5	..	..
Cattle Quarantine Station	Foot-and-mouth disease	2	..	..	2	..	..
	Anthrax	29	..	29	..	..	..
Central	Foot-and-mouth disease	562	125	3	514	45	..
	Anthrax	5	..	5	..	..	..
	Rabies	9	..	2	..	..	7
	Contagious mange	18	..	2	16	..	..
	Blackquarter	9	..	8	..	..	1
	Piroplasmosis	10	..	2	8	..	..
Southern	Foot-and-mouth disease	665	..	31	634	..	..
	Haemorrhagic Septicaemia	6	2	6	..	..	..
	Rabies	11	6	..	..	..	11
Northern	Foot-and-mouth disease	130	..	7	123	..	..
	Blackquarter	60	60	59	1	..	..
	Rabies	1	..	..	..	..	1
Eastern	Foot-and-mouth disease	5	..	..	5	..	..
	Anthrax	48	..	48	..	..	..
North-Western	Foot-and-mouth disease	122	..	3	119	..	..
	Contagious Mange	18	..	..	18	..	..
	Rabies	12	1	2	..	..	10
	Piroplasmosis	1	..	..	1	..	..
	Haemorrhagic Septicaemia	23	..	23	..	..	..
North-Central	Foot-and-mouth disease	1,695	..	10	1,685	..	..
	Blackquarter	31	..	31	..	..	..
Uva	Foot-and-mouth disease	223	109	20	110	93	..
Sabaragamuwa	Rabies	5	..	..	..	..	5
	Haemorrhagic Septicaemia	1	..	1	..	..	..

Department of Agriculture,
Peradeniya, November 18, 1939.

M. CRAWFORD,
Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, OCTOBER, 1939

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	DAY	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	84·8	+0·1	75·1	+0·2	80	93	8·0	12·83	23	— 0·42
Puttalam ..	87·8	+1·8	76·8	+1·5	74	88	6·8	2·75	11	— 5·33
Mannar ..	87·3	+0·1	77·8	+0·6	76	86	7·8	3·13	12	— 3·86
Jaffna ..	86·2	+0·8	77·8	+0·3	79	84	6·4	7·84	15	— 1·74
Trincomalee ..	88·5	+0·8	75·0	—0·6	76	90	6·5	19·28	22	+10·14
Batticaloa ..	87·4	+0·4	75·2	0	74	88	5·2	11·86	18	+ 4·79
Hambantota ..	87·4	+1·5	76·2	+1·2	75	86	6·0	0·93	13	— 3·89
Galle ..	83·1	+0·2	75·9	+0·5	78	86	7·4	12·16	19	+ 0·53
Ratnapura ..	85·5	—1·8	73·2	+0·6	85	95	6·0	14·21	27	— 3·63
Anuradhapura ..	90·3	+1·6	73·2	—0·2	72	95	6·5	9·72	19	— 0·05
Kurunegala ..	87·5	+0·1	74·1	+1·0	74	90	6·0	12·15	21	— 3·69
Kandy ..	84·0	+0·1	68·9	+0·3	76	95	8·0	7·93	26	— 2·94
Badulla ..	83·6	+0·6	66·1	+0·7	67	92	6·4	9·45	15	— 0·27
Diyatalawa ..	77·0	+0·6	60·6	+0·1	68	91	6·9	9·84	19	+ 0·33
Hakgala ..	70·6	+0·7	55·5	—0·1	82	91	6·4	4·89	17	— 7·91
Nuwara Eliya ..	68·2	+0·4	53·2	+1·7	83	94	8·7	4·86	26	— 5·78

Excesses and deficits of rainfall were rather irregularly distributed during October, but on the whole, excesses predominated. Broadly speaking, excesses were most marked in the south-west and the north-east, while negative offsets were the rule in the north-west and the south-east. Upper Ohiya and West Haputale, at the south-eastern edge of the main hill masses, recorded the largest deficits of 11·38 and 11·26 inches respectively. The largest excess was 12·90 inches at Kanana in the Kalutara District, while three other stations, Andankulam, Kanukkeni and Trincomalee, all in the north-east, recorded excesses of over 10 inches.

The highest monthly total was 36·70 inches at Pimbura. Other totals of over 35 inches were 36·16 inches at Dabar and 35·73 inches at Carney, while 7 other stations, all in the south-west of the Island, recorded totals of over 30 inches for the month.

There were altogether 20 cases of daily falls of over 5 inches, the largest being 7·38 inches at Kobonella on the 27th. The majority of these falls occurred between the 27th and 31st.

During the first week of the month, there was a moderately steep south-westerly gradient, and an appreciable amount of rain of monsoonal origin was experienced in the south-west of the Island. From the 15th to the 19th, as a result of unsettled conditions, widespread rain occasionally heavy occurred in the south-west. During the rest of the month, afternoon and evening local thunderstorms accounted for a fair amount of irregularly distributed rain.

Temperatures were in general slightly above normal. Humidity was on the whole above average, and cloud amount slightly in excess. Winds were above normal strength, the general direction being south-westerly.

A hailstorm was reported from Diyatalawa on the afternoon of the 18th.

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EDITORIAL

CAPITAL AND FARMING

"IF a man has a capital of Rs. 12,000 why should he go on the land ?" This was a question, more rhetorical than interrogatory, asked at the last meeting of the Central Board of Agriculture by a member who is a more sincere, vigorous, and uncompromising champion of the back-to-the-land-movement than any other. The tolerant, if not sympathetic, reception that the question had in this assembly of agriculturists may be regarded as evidence that the scale of social and economic values underlying it is commonly accepted in the country. Yet this scale of values is so inconsistent with the rapid development of agriculture in the country and with the consummation of the policy of self-sufficiency which the country has adopted as its fixed, if somewhat distant, aim that it merits some examination and analysis.

In a reference to the survey of the paddy growing industry in Burma in the last number of this Journal, it was pointed out that in that country the size of the average holding was about 25 acres, that it was the size of the holding which produced an exportable surplus above the requirements of the farmer for personal consumption, and that Ceylon could feed herself with her own produce of rice without engaging the whole population in paddy growing only by raising the size of the individual holding to something near the Burmese level. The Special Committee of the Planters' Association that studied the problem of paddy cultivation in 1920—not academically but as practical business men drawing up a prospectus for a company which they were going to invite their principals to finance—estimated the minimum cost of bringing an acre of land under the plough at Rs. 200, and thought that, under the unfavourable conditions in which new land has to be opened up in paddy, it might go up to Rs. 400 ; the latter figure finds confirmation in the general experience of the Department of Agriculture. Taking the intermediate figure of Rs. 300 per acre, the cost of the clearing, levelling, and ridging of a farm of 25 acres is Rs. 7,500. Other necessary items such as fencing, houses and a bare minimum of furniture for the tenant and two labourers, a well for drinking

water and the necessary live and dead stock will absorb at least Rs. 2,500 more. Fluid working capital of Rs. 1,000 will bring the total up to Rs. 11,000. Therefore the speaker could not have intended to convey the impression that paddy farming did not require capital. He meant either that the owner of this amount of wealth need not work but could live the comfortable life of a man of leisure by the safe investment of his money or that the owner of Rs. 12,000 should embark on a more remunerative or a more noble form of occupation, leaving paddy cultivation to the destitute who willl adopt it as the resort of despair. At the current rate of interest for safe investments the annual income from Rs. 12,000 would be about Rs. 425. It is suggested that neither the speaker nor the rest of the country would or should accept this figure as the measure of an adequate standard of living at which all further effort might be suspended, for then there would be no room in Ceylon for any improvement either in agriculture or in any other form of industrial activity. Therefore the true meaning of the question is the suggestion that paddy cultivation should be left to the indigent. But the indigent working with no capital, or with minor subsidies from Government, cannot produce a surplus for the market, and there will be no substantial increase in rice production unless the country sheds this sentiment the general prevalence of which is confirmed by the absence of a single recorded case of a man who advises others from the platform or the press to become paddy farmers seeking to set up his son as a paddy farmer.

Admittedly rice growing is not an adequately remunerative industry on the basis of the ruling competitive prices of commodities; but Government has sought to make the occupation reasonably remunerative by the enforcement of the Agricultural Products (Regulation) Ordinance; but that ordinance will remain ineffective so long as men of the standing of the members of the Central Board of Agriculture entertain the notion that the owner of a bare modicum of capital must shun rice farming.

CEYLON'S FOOD SUPPLY

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IN view of the intensive action that is about to be taken to increase the production of food crops in Ceylon, a consideration of the figures presented in this article in regard to supplies which are brought in from abroad may prove of interest and some value. Fortunately accurate statistics are available in the Ceylon Customs Returns from which official source the figures quoted are taken. Unfortunately, however, statistics relating to cultivated food crops in the Island are not available—even those for the paddy industry are of doubtful accuracy—so that it is not possible to compute the extent of domestic production and to arrive at a ratio of local products to imports. Whether or not it is intended to make Ceylon self-supporting in the matter of all or any of the food crops, the information herein presented should prove of value in a consideration of this question and of the country's dependence upon outside sources for her supplies. In arriving at the per capita figures, the population of the Island has been taken as six millions; and in regard to home-produced rice the yield is estimated at 30 bushels of paddy per acre per annum and the cultivated area taken as 850,000 acres.

The total value of imported foodstuffs, inclusive of fish and meat, amounted in 1938 to Rs. 98 millions or Rs. 16·30 per head of population. Omitting fish, as not being an agricultural commodity, which accounted for Rs. 14 millions or Rs. 2·30 per head, the value of vegetable and animal foodstuffs was Rs. 84 millions or Rs. 14·00 per head Meat—beef, mutton, pig products, live animals for food, and eggs—was valued at Rs. 1 2/5 millions which works out at 23 cents per head. The value of vegetable products alone, therefore, amounted to Rs. 82·6 millions or Rs. 13·87 per head. Of this sum a little over 66 per cent. or Rs. 55 millions, working out at Rs. 9·20 per head, was the value of rice and paddy imported in 1938. Sugar accounted for Rs. 8 millions or Re. 1·30 per head, leaving Rs. 19¾ millions, equivalent to Rs. 3·37 per head, for the rest of the vegetable foodstuffs. Table I shows the total value and the value per head of the different classes of commodities imported in 1938. From this it will be observed that over half the total food bill is set against the staple food

rice. Each head of the population paid in 1938 over Rs. 9·00 for his supply of foreign rice. Table II shows that 18½ million bushels of rice and paddy converted into rice (actually 10½ million cwt. of rice and 172,000 cwt. of paddy) were imported and that this was equivalent to 3 1/10 bushels per head. At the accepted rate of half a bushel per head per mensem this suffices for a period of 6 months. Home production is estimated at 12¼ million bushels of rice equivalent to 2 bushels per head sufficient for 4 months. This affords a total of 5 1/10 bushels per head from both sources. The main source of our supplies is Burma to which country we remitted last year the large sum of Rs. 33⅓ millions equivalent to Rs. 5·70 per head. British India claims a sum of nearly Rs. 15 millions, and Siam Rs. 6 millions. Less quantities were also imported from Cochin China and the Straits Settlements. Further discussion will not be entered into as the problem of the rice industry is a subject which is both big and complicated and merits a separate treatise. Of Rs. 8 millions paid out on imported sugar, Rs. 7 millions went to Java alone for 1¼ million cwt. of refined sugar, smaller quantities of which were also obtained from Portuguese East Africa and Hong Kong. Of unrefined sugar imported to the extent of 55,000 cwt. and valued at Rs. 369,000, it is significant that nearly 21,000 cwt., classified as jaggery, were imported from British India at a cost of Rs. 167,000. With the removal of the restriction on tapping for sweet toddy, it is to be hoped that the jaggery industry will come into its own again and prevent a lakh and a half of rupees going out of the country. Intensive propaganda and facilities for improved manufacture and marketing, however, are required.

Onions comprise both the Spanish type (popularly termed "Bombay" onions in Ceylon) and the small, red or curry "onion" which, properly, should be designated "shallot." If the former type cannot be grown in the Island, there certainly is no reason why the latter should not. The question of price is probably the deciding factor, and if this is so, it may be worth while considering whether a bounty should not be paid to cultivators in order to save even fifty per cent. of the Rs. 2 millions which go out of Ceylon annually for this essential commodity.

Whether anything can be done in the matter of raising potatoes which claimed Rs. 1⅓ millions last year awaits consideration.

Leguminous seeds comprising beans, gram, and pulses were imported at the rate of 11⅓ lb. per head and absorbed no less than Rs. 3½ millions. These were imported mainly from British India and Burma as well as China. But it surely is an anomaly that we should allow imports under this head from

Siam and Java to the value of Rs. 37,000 and Rs. 13,000 respectively, and even from the Straits Settlements to a less extent. There is a very strong case for the extensive as well as intensive cultivation of leguminous food crops in Ceylon, the "straw" and chaff of which form good material as food for stock.

The bill for currystuffs has always been a high one and amounted in 1938 to Rs. 4 1/5 millions; and of this sum a little over 60 per cent. or Rs. $2\frac{2}{3}$ millions went on the single commodity "dried chillies" which were imported at the rate of $3\frac{1}{3}$ lb. per head of population. It may not be possible to grow in Ceylon many of the crops which are grouped under this head, but chillies are certainly a possibility and, as in the case of curry onions, it seems necessary to offer a subsidy to growers of this crop. The bulk of the currystuffs comes from British India to which country a sum of Rs. 2,692,000 was paid in 1938. Nearly half this sum went on chillies alone. It is scarcely conceivable that we should allow dried chillies to the value of half a million rupees to be imported from the Straits Settlements.

Garlic and turmeric to the value of Rs. 234,000 and Rs. 145,000 respectively, were imported in 1938, the former from the Straits Settlements chiefly and latter from British India. It will be seen that, if both these crops are grown in Ceylon, nearly 4 lakhs of rupees may be retained in Ceylon.

The value of imported tamarind was Rs. 265,000, and in addition to British India this commodity was also obtained from Java and the Straits Settlements. Is all the available tamarind in the Island collected and marketed or does much of it go to waste? Some inquiry seems desirable as also a consideration of the question of planting it as a roadside tree as is done for miles along the highways in the Madras Presidency.

In looking through the returns of last year one is struck by the extraordinary fact that no less an article than pepper, which a few years ago was being exported from Ceylon to the value of Rs. 4 lakhs, was actually imported from the Straits Settlements and British India to the extent of 2,700 cwt. and 260 cwt. respectively. The value of these quantities was Rs. 38,000. The market for Ceylon pepper has been down during the past few years and imports dropped to nil; but what became of available stocks and how is it that this has not been marketed locally to avoid imports from abroad? Enterprise is decidedly lacking in Ceylon, as well as appreciation of home-grown produce. But, fortunately, the Government Marketing Department is slowly but surely coming to the rescue of the country. Under the heading "fruit" are included fresh and dried fruit and fruit preserved in syrup and in the

form of jams and jellies. The value of these imports in 1938 was Rs. 1 1/10 millions, of which sum a little over 50 per cent. was remitted to Australia. Fresh fruit, chiefly apples and grapes, came mainly from Australia and the United States of America. Dried dates accounted for nearly a lakh of rupees, but, unfortunately, the local boutiques are flooded with stuff of very poor quality which is retailed at 10 cents and even less a pound.

Of oils and fats for human consumption, Australia sent frozen and tinned butter to the value of Rs. 545,000, and Holland, vegetable ghee to the value of Rs. 123,000. The value paid per head of population for these commodities is 16 cents which is not high, but account must be taken of the large consumption of locally-produced coconut oil and the use of coconut milk in cooking of which no estimate is possible.

Cakes, biscuits and confectionery, the bulk of which came from the United Kingdom, accounted for nearly one million rupees.

The bill for prepared cocoa is unaccountably small and shows that the nutritive value of this important article of diet is not sufficiently appreciated in Ceylon.

Java exported to Ceylon not less than Rs. 500,000 worth of coffee beans and British India Rs. 29,000 worth of beans and roasted coffee in 1938.

The total payment and the amount paid per head of population for food to the major exporting countries in 1938 are as follows :—

Source of supply.	Total Value of Imports. Rs. mill.	Amount per Head of Population. Rs. c.
Burma	34·0	5 70
British India	24·0	4 2
Java	7·6	1 27
Siam	6·0	0 86
Australia	4·0	0 67
United Kingdom	1·7	0 29
Holland	1·3	0 22
Straits Settlements	0·9	0 15
Other countries	4·5	0 82

This article purports no more than to furnish a preliminary statement regarding the Island's dependence upon foreign food supplies, and will be followed by a further one in which will be discussed the practical aspects of local production in order to save as large a proportion as possible of the heavy bill to which Ceylon is committed on the score of food.

TABLE I.

	Items.	Total Value.		Value per Head of Population.
	Classes of Food Stuffs.	Rs. mill.		Rs. c.
1.	Rice and paddy ..	55·0	..	9 20
2.	Sugar	8·0	..	1 30
3.	Currystuffs	4·2	..	0 70 (1)
4.	Legumes	3·5	..	0 58
5.	Onions and potatoes ..	3·3	..	0 55 (2)
6.	Milk and milk products excluding butter and ghee taken under 10	3·3 2·6	.. ..	0 55 0 43
7.	Cereal flour and prepared foods ..	2·0	..	0 33
8.	Meat (all kinds)	1·4	..	0 23
9.	Fruit (fresh, dried, and preserved)	1·1	..	0 18
10.	Oils and fats (animal and vegetable)	1·0	..	0 16
11.	Cakes, biscuits, and confectionery	0·9	..	0 15
12.	Cocoa and coffee ..	0·5	..	0 8
13.	Oil seeds (for food) ..	0·3	..	0 5
14.	Vegetables (fresh and preserved)	0·09	..	0 1½
15.	Fish (all types)	14·0	..	2 30

(1) dried chillies Rs. 2⅔ mill. = 0·38 cts.
(2) onions Rs. 2 ,, = 0·33 ,,
potatoes Rs. 1¼ ,, = 0·22 ,,

TABLE II.

Items.	Total Imports Quantity.		Quantity per Head of Population.
Rice and paddy converted into rice ..	18½ mill. bushels		$3\frac{1}{10}$ bushels
Sugar, refined	1⅔ mill. cwt.	..	26¾ lb.
Onions	661,000 cwt.	..	12⅓ lb.
Beans, gram, and pulses ..	605,000 cwt.	..	11⅓ lb.
Potatoes	270,000 cwt.	..	5 lb.
Chillies	178,000 cwt.	..	3⅓ lb.
Sugar, unrefined	55,000 cwt.	..	1 lb.
Milk (preserved and powder) ..	4½ mill. lb.	..	¾ lb.
Butter and ghee (animal and vegetable)	2⅙ mill. lb.	..	⅓ lb.
Beef, mutton and pig products (excluding preserved game and live animals of which quantities are stated in number)	13,700 cwt.	..	¼ lb.
Fish—			
dried or salted	380,000 cwt.	..	7 lb.
Maldive	87,000 cwt.	..	1⅔ lb.

THE ANALYSIS OF CEYLON FOODSTUFFS
VI.—THE MORE IMPORTANT FRUITS OF THE ISLAND

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IN part IV of the series of papers in *The Tropical Agriculturist* of January, 1938, on the analysis of Ceylon foodstuffs (1), the results of the vitamin C determinations of some local fruits and vegetables were presented and discussed. In this paper the analytical data of the more important fruits of the Island are detailed and compared. The number of samples examined was twenty-two comprising twenty different species of fruits. These were plantain, mango, pineapple, papaw, mangosteen, grapefruit, orange, lime, guava, tomato, tree tomato, jak, bael, woodapple, soursop, custard apple, bullock's heart, sapodilla, avocado pear, and young coconut. Two varieties each of the plantain and the mango were studied for purposes of comparison.

SOURCE OF SUPPLY, SAMPLING AND METHODS OF ANALYSIS

Samples for analysis were obtained locally and were representative of the fruit of the district. Fully-ripe fruits were selected and only the edible portion of the fruit was analysed, the percentage of such portion on the whole fruit being determined in every instance. The figures so obtained are included in the table. The methods of analysis for the constituents determined were mainly those adopted by McCance, Widdowson, and Shackleton (2) in their work on "The Nutritive Value of Fruits, Vegetables and Nuts." The following determinations were carried out on the samples by the methods indicated in brackets:—moisture (drying at 50°C), mineral matter (incineration in a muffle furnace), protein (nitrogen by Kjeldhal method × 6·25), fat (extraction in a Soxhalet apparatus), total and reducing sugars (Lane and Eynon's method on alcoholic extract), fibre (digestion with acid and alkali), titratable acidity (on alcoholic extract), calcium and phosphorus (volumetric phospho-molybdate method). Total carbohydrates were obtained by difference

and the calorific value calculated by the usual method. Iron determinations were not carried out, as the amount of this element in fruits is generally very low. Further, large variations have been observed in the iron contents of different samples of the same fruit.

The results of analysis are furnished in the annexed table. They are expressed as percentages on the edible portion of the fruit. It need hardly be stressed that these figures are merely indicative of the general analytical composition of the particular variety of fruit and would vary fairly appreciably with different samples of the same fruit, particularly in respect of the mineral constituents. As a matter of interest, in addition to the English names, the botanical, Sinhalese and Tamil names of the fruits are given.

THE COMPOSITION OF FRUITS IN GENERAL AND CEYLON FRUITS IN PARTICULAR

Fruits contain high percentages of water, the latter varying from 65 to 90 per cent. Of the local fruits examined, bael is a striking exception, its moisture content being only 44 per cent. Other fruits with relatively low moisture contents are the *kolikuttu* plantain and bullock's heart (which contain about two-thirds their weight of water), and jak (pulp).

The edible portions of fruits constitute, in the majority of cases, from 40 to 85 per cent. of their weight, the exceptions being young coconut (kernel) with only 7 per cent. and jak (pulp) with 31 per cent. of edible flesh on the one hand, and tomato with 97 per cent. and guava with 100 per cent. edible matter on the other. Most varieties of guava have, however, a high proportion of seeds which are in reality waste material.

The other constituents of fruits are: carbohydrates comprising sugars, starches (in small amounts only), gums, pectins and fibre, organic acids which with the sugars determine fruit flavour, mineral matter, proteins, and fats in small quantities (with certain noteworthy exceptions), essential oils and esters, which give them their aroma, vitamins and colouring matter. The characteristic vitamin of fruits is vitamin C, but certain fruits, *e.g.*, mango, papaw, plantains, avocado pear, contain vitamin A or carotene in relatively fair quantities. Some local fruits such as the papaw and pineapple contain proteolytic enzymes, *papain* being obtained from the former and *bromelin* from the latter.

Carbohydrates.—The carbohydrate figures, which as already explained are obtained by difference, would vary to an appreciable degree with the moisture contents of the fruits. In the case of the fruit samples examined, the amount of carbohydrate

varies from 3·2 per cent. in young-coconut kernel to 52·0 per cent. in bael fruit. The plantain, jak, custard apple, sapodilla, and bullock's heart are also relatively rich in carbohydrates, while the avocado pear, young-coconut kernel, tomato, and lime are poor in these food constituents. Sugars constitute over 50 per cent. of the total carbohydrates in the mango (particularly the parrot mango which is noted for its sweetness), ripe plantain, jak, sapodilla, papaw, and mangosteen. The guava has been reported (3) by workers in Bombay to be rich in sugars, but the sample examined here, which was of the local variety, was found to be otherwise. Fruits which have only traces of sugar are the tomato, avocado pear, and lime. In the bael fruit and woodapple less than 20 per cent. of the carbohydrates consists of sugars. Starches and mucilages in the former and pectins and other such compounds in the latter probably constitute the main bulk of their carbohydrates. In most fruits the cane sugar content is higher than that of the reducing sugars. The reverse holds in the case of the plantain. The latter finding is confirmed by the work of Widdowson and McCance (4) with bananas, but not by that of Poland, &c. (5). The discrepancy in results is probably due to differences in variety of fruit and possibly methods of analysis.

Ether Extract—Oil and Fat.—The avocado pear and the young-coconut kernel are outstanding in respect of their fat contents. The local sample of the former contained 17·5 per cent. of oil or over 70 per cent. of the dry matter of the fruit pulp. The latter contained 10·8 per cent. of oil or over 50 per cent. of the dry matter of the kernel. Work in California (6) and India (7) has confirmed the results obtained locally with the avocado. The name "butter fruit" by which this fruit is also known is well-deserved. The other local fruits, with the exception of the sapodilla, have very low fat contents.

Fibre.—The fibre figures need but little comment. The woodapple and guava (the latter owing to its seed) have highest fibre contents. The young-coconut kernel has more fibre than might be expected.

Protein.—The protein contents of all local fruits are low. Woodapple has approximately 3 per cent. protein, while bullock's heart, custard apple, young-coconut kernel, jak, and bael have about 2 per cent. of this constituent. Mangoes, guavas, and plantains have only about one per cent. of protein.

Calorific value.—Bael fruit, avocado pear and *kolikuttu* plantain have highest calorific values, with bullock's heart and jak pulp closely following. These fruits have from about a third to a half of the calorific value of energy foods such as cereals.

Titratable acidity.—This varies from 8 c.c. of N/10 acid per 100 g. for the *kolikuttu* plantain to 954 c.c. for lime. The woodapple is strongly acid with an acidity value of 537 c.c., while other fruits with high acid contents are the tomato, tree tomato, orange, grapefruit, pineapple, and soursop. The sapodilla, papaw, and avocado pear contain but little acid. The sour plantain has an acid value similar to that of the parrot mango.

Mineral matter.—The percentage of mineral matter varies from 0·16 per cent. in the mangosteen to 1·72 per cent. in the bael fruit. The woodapple, bullock's heart, and avocado pear also have high ash contents. Of all the constituents of fruits, none are likely to vary so much in different samples of the same fruit as the individual mineral constituents.

Calcium.—The calcium contents vary from 4·3 mgm per 100 g. for sapodilla to 80·4 mgm per 100 g. for woodapple. The interesting point is that while woodapple has a high titratable acid value, it has also a high calcium content. The latter fact has been confirmed by Indian workers (7). But the calcium contents of local fruits are lower than those of corresponding samples analysed in India. Other fruits which contain relatively high amounts of calcium are bael, bullock's heart, and orange. Besides the sapodilla, fruits low in calcium are mangosteen, plantain, avocado pear, tree tomato, and pineapple. The sample of sapodilla examined was grown on a sandy soil, deficient in lime. Hence, perhaps, its low calcium content.

Phosphorus.—The phosphorus contents of the fruit samples examined range from 6·3 to 55·6 mgm per 100 g. The following fruits show low values: papaw, mangosteen, tomato, parrot mango, guava. Woodapple is richest in this constituent also, others showing high values being bael, young-coconut kernel and avocado. Compared with the Indian figures (7) the phosphorus contents of local fruits are invariably lower.

GENERAL DISCUSSION AND SUMMARY

The results of analyses of 22 samples comprising 20 species of local fruit, generally confirm the findings of workers in India (7) and the Philippine Islands (8) in regard to the composition of the fruits examined. Differences are, however, apparent particularly in regard to the mineral contents. The Indian figures for calcium and phosphorus are invariably higher than the corresponding local figures. Climatic and soil differences would account for this fact.

Local fruits, like most fruits, have (1) high moisture contents, a notable exception being the bael fruit, (2) low percentages of protein, (3) traces of fat, except in the avocado pear and young-coconut kernel, which are both rich in this constituent, (4)

CHEMICAL COMPOSITION OF CEYLON FRUITS

Fruit.	Botanical Name.	Sinhalese Name.	Tamil Name.	Nature of waste.	Edible portion per cent.	Moisture per cent.	Protein per cent.	Total carbohydrates per cent.	Reducing sugars per cent.	Sucrose per cent.	Total sugars per cent.	Ether extract (fat) per cent.	Fibre per cent.	Mineral matter per cent.	Calcium mgm per cent.	Phosphrous mgm per cent.	Titratable acidity c.c. N/10 per 100 g.	Calorific value per 100 g.	
1 Sour plantain ..	*Musa paradisica* .	Ambulhondara-vala	Pulikathali ..	Skin ..	69	73·6	1·09	24·44	13·0	3·6	16·6	0·14	—	0·73	13·4	15·8	49	103·4	1
2 Kolikuttu plantain	*Musa paradisica* .	Kolikuttu ..	Kappal ..	Skin ..	72	65·9	1·28	31·71	14·4	8·2	22·6	0·21	—	0·90	9·9	19·5	8	133·9	2
3 Avocado pear ..	*Persea drymifolia* .	Aligata pera ..	Seemai Koiya ..	Skin and seed ..	28	75·6	0·85	4·97	—	—	—	17·55	—	1·03	10·9	35·4	12	181·2	3
4 Grapefruit ..	*Citrus grandis* var. *maxima*	Seeni-jambola .	Krape thodam palam	Skin, seeds, pith, and membranes	55	88·3	0·50	10·68	3·4	2·2	5·6	0·13	0·04	0·35	20·4	12·5	173	45·9	4
5 Orange ..	*Citrus auranium* ..	Peni-dodan ..	Thodam palam ..	do. ..	53	86·4	0·59	12·28	2·4	3·5	5·9	0·17	—	0·56	37·0	18·7	171	53·0	5
6 Lime ..	*Citrus medica* var. *acida*	Dehi ..	Elimichai palam .	do. ..	55	90·3	0·51	8·60	—	—	—	0·16	—	0·43	18·8	16·1	954	37·9	6
7 Papaw ..	*Carica papaya* ..	Papol (Gas-labu)	Papasi palam ..	Skin and seeds ..	67	85·1	0·39	14·06	1·0	6·7	7·7	0·07	—	0·38	18·8	6·3	12	58·4	7
8 Mango, Jaffna ..	*Mangifera indica* .	Yapane amba ..	Vellai columban ..	Skin and seed ..	54	80·0	1·08	17·09	4·7	8·4	13·1	0·20	0·23	0·40	24·0	20·9	69	74·5	8
9 Mango, Parrot ..	*Mangifera indica* .	Gira amba ..	Kilichondu mampalam	Skin and seed ..	56	85·9	0·62	12·70	3·5	7·8	11·4	0·07	0·27	0·44	19·3	7·4	45	53·9	9
10 Tomato ..	*Lycopersicum esculentum*	Thakkali ..	Thakkalip palam	Stem ends ..	97	93·9	0·64	4·86	—	—	—	0·01	—	0·59	15·7	9·5	132	22·1	10
11 Tree Tomato ..	*Cyphomandra betacea*	Gas-thakkali ..	Marathakkalip palam	Skin and stalks ..	79	84·6	1·95	9·88	1·8	1·6	3·4	0·53	2·24	0·80	13·3	30·5	263	52·1	11
12 Pineapple ..	*Ananas sativas* ..	Annasi ..	Annasip palam ..	Stem, crown, skin, and core	42	87·8	0·49	10·91	3·3	4·9	8·2	0·07	0·32	0·41	13·5	15·0	158	46·2	12
13 Mangosteen ..	*Garcinia mangostana*	Mangus ..	Mangusthan palam	Skin and seeds ..	70	82·6	0·60	16·48	1·9	6·5	8·4	0·16	—	0·16	5·7	9·4	81	69·8	13
14 Jak fruit ..	*Artocarpus integrifolia*	Waraka ..	Pilap palam ..	Skin, membranes, and seeds	31	68·8	1·81	27·54	4·0	14·4	18·4	0·29	0·65	0·91	16·9	17·0	35	120·0	14
15 Bael fruit ..	*Aegle marmelos* ..	Belli ..	Vilvam palam ..	Shell and seeds ..	48	44·0	1·77	52·03	2·6	7·2	9·8	0·48	—	1·72	46·8	54·1	82	219·5	15
16 Wood apple ..	*Feronia elephantum*	Diwul ..	Villam palam ..	Shell ..	58	74·0	2·91	17·08	1·3	0·4	1·7	0·71	3·90	1·40	80·4	55·0	537	86·4	16
17 Soursop ..	*Anona muricata* ..	Katu-anoda ..	Mulannamuna palam	Skin, seeds, and core	69	82·4	0·88	14·97	6·2	1·0	7·2	0·19	0·78	0·78	19·4	31·9	124	65·1	17
18 Bullock's heart ..	*Anona retuculata* .	Anoda ..	Parangi annamuna palam	do. ..	41	66·4	2·06	29·41	6·8	0·5	7·3	0·54	—	1·59	64·1	19·9	88	130·7	18
19 Custard apple ..	*Anona squamosa* .	Seeni-anoda ..	Annamuna palam	do. ..	47	76·4	2·09	20·44	7·3	2·3	9·6	0·24	—	0·83	17·8	14·1	78	92·3	19
20 Sapodilla ..	*Achras sapota* ..	Sapodilla ..	Seemai ellupai ..	Skin and seeds ..	86	71·5	0·75	25·21	8·0	8·7	16·7	1·10	0·97	0·47	4·3	23·9	18	113·7	20
21 Guava (Hill) ..	*Psidium guajara* .	Pera ..	Koiya palam ..	Nil ..	100	82·0	1·07	10·01	3·9	1·4	5·3	0·27	5·98	0·67	19·8	11·5	79	46·8	21
22 Young-coconut kernel	*Cocos nucifera* ..	Kurumba ..	Thenkai valuval ..	Husk, shell, and water	7	81·1	1·97	3·23	·5	·5	1·0	10·84	1·88	0·98	15·2	51·1	—	118·4	22

relatively high amounts of carbohydrates, the greater proportion of which is, in many cases, cane and reducing sugar, (5) varying quantities of organic acids—lime and woodapple being the most acid of those examined, (6) mineral constituents in very variable proportions, (7) vitamins, mainly vitamin C, though a few are relatively well-supplied with vitamin A or its precursor carotene, (8) essential oils and esters which give the aroma to the fruits.

No details are given in this paper of the vitamin contents of local fruits as these have been furnished in a previous publication (1). The papaw and the pineapple are characteristic in that they contain proteolytic or protein-hydrolysing enzymes of commercial value. Thus the papaw supplies *papain* and the pineapple *bromelin.*

Of the fruits examined bael, avocado pear, plantains (the *kolikuttu* variety) and young-coconut kernel have highest calorific values, the high oil content of the avocado and young-coconut kernel contributing to this result. Plantains, jak, sapodilla, and mangoes are rich in sugars. Woodapple is richest in both calcium and phosphorus, bullock's heart and bael fruit being also good sources of these elements. The fruits containing largest amounts of fruit acids are lime, woodapple, and tree tomato.

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ANALYSIS OF CEYLON FOODSTUFFS

VII.—FURTHER ANALYSES OF LOCAL FOODSTUFFS WITH PARTICULAR REFERENCE TO THEIR MINERAL COMPOSITION

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SINCE the publication of the articles on the analysis of Ceylon foodstuffs in *The Tropical Agriculturist* of January, 1938 (1), analyses have been made of locally-grown foods which had not been examined or had only been partially examined before. The results of these analyses are now published, as they may be of value to those who are interested in the practical aspects of nutrition in the Island. The paper has, for the sake of convenience, been divided into two sections. The first deals with the analyses of 18 varieties of grains, roots, yams, tubers, and seeds; the second with the comparative mineral composition of 23 vegetable samples obtained from three important marketing centres. The data are presented in three tables.

In all cases, only the edible portion of the foodstuff was analysed. The methods of analysis adopted were the same as in the earlier investigations, except in regard to the iron determinations for which a Lovibond tintometer was used in making the colour comparisons. Some of the iron results were checked by the thioglycollic acid method. Potassium was estimated in a few samples by the volumetric cobaltinitrite method.

SECTION I.

The foodstuffs examined were the yellow, purple, and white varieties of adlay, dried palmyra root (raw and parboiled), wild breadfruit and *Cycas* seeds (*madu* S.), dioscorea, alocasia and colocasia yams, artichoke (local), country potato (*innala* S.), and young-coconut water. The mineral constituents of gingelly, king yam, and sweet potato were also determined. Table I shows the proximate composition of the foods mentioned and Table II their mineral composition. In the latter table, the mineral analyses of local samples of rice, green gram, and kurakkan, which have already been published in part, are included for comparison. Attention may be drawn to the magnesium data which are presented for the first time. Rice is poorer in this mineral constituent than kurakkan or green gram.

TABLE I

The Composition of Local Foodstuffs.

Name.	Botanical Name.	Sinhalese Name.	Tamil Name.	Moisture Per Cent.	Protein Per Cent.	Carbo-hydrate Per Cent.	Ether Extract Per Cent.	Fibre Per Cent.	Mineral Matter Per Cent.	Calorific Value per 100 Gms.
Grains, Seeds, and Roots—										
Adlay (yellow)	Coix lachryma-jobi	Kirindi	Netpavalam	11·3	10·3	74·3	3·1	0·29	0·70	366·3
,, (purple)	do.	do.	do.	10·2	11·7	73·1	3·8	0·32	0·87	373·4
,, (white)	do.	do.	do.	10·1	12·1	72·7	3·8	0·31	0·99	373·4
Wild breadfruit seed	Artocarpus nobilis	Wal-del, bedi-del	Asinippala	7·8	13·1	42·7	34·2	—	2·2	541·0
Cycas seed	Cycas circinalis	Madu	Madukoddai	11·0	12·3	72·9	1·5	0·43	1.9	354·3
Dried Palmyra root (raw)	Borassus flabellifer	Kottaikilangu	Odiyal	15·6	3·8	75·7	1·0	1·8	2·0	327·0
,, ,, (parboiled)	do.	do.	Pulukkodiyal	13·4	4·6	77·2	1·2	1·6	2·1	332·0
Yams, Tubers, &c.—										
Coco	Alocasia indica	Desaiala	Sembu	77·7	1·2	18·8	0·13	0·45	1·6	81·2
Taro, Tannia	Colocasia antiquorum	Gahala or I[illegible]hiala	do.	67·2	1·8	29·6	0·12	0·42	0·85	126·1
Country potato	Coleus parviflorus	Innala	—	77·6	1·3	19·7	0·18	0·35	0·87	84·7
—	Dioscorea bulbifera	Udala	Mothakavallie	82·5	0·96	15·3	0·13	0·42	0·63	66·4
Artichoke, Jerusalem	Helianthus tuberosus	—	—	79·7	1·9	16·7	0·03	0·59	1·1	74·7
Young coconut water	Cocos nucifera	Kurumba	Ilaneer	94·8	0·08	4·2	0·10	—	0·51	17·3
King coconut water	do.	Tambili	Sevilaneer	94·5	0·07	4·3	0·11	—	0·44	17·3

TABLE II

The Mineral Composition of Local Foodstuffs.

Name.	Moisture Per Cent.	Mineral Matter Per Cent.	Calcium Per Cent.	Phosphorous Per Cent.	Iron Mgm. Per Cent.
Yams, Roots, and Tubers—					
King yam (Jaffna)	75·3	0·77	0·01	0·09	1·1
Sweet potato	72·7	0·58	0·03	0·02	0·8
Desaiala (1)	77·8	1·6	0·02	0·10	—
,, (2)	75·2	1·4	0·02	0·11	—
Gahala or Dehiala (1)	67·2	0·85	0·02	0·12	—
,, (2)	70·3	0·98	0·04	0·14	—
Innala	77·6	0·87	0·03	0·05	—
Artichoke	79·7	1·1	0·02	0·08	—
Palmyra root (raw)	15·6	2·0	0·04	0·17	—
,, (boiled)	13·7	2·1	0·03	0·17	—
Udala (aerial tuber)	82·5	0·63	0·01	0·02	—
Grains, Oil Seeds, &c.—					
Gingelly	6·4	6·5	1·39	0·47	19·6
,,	6·0	6·6	1·38	0·50	10·7
Adlay (yellow)	11·3	0·70	0·005	0·30	—
,, (purple)	10·2	0·87	0·006	0·40	—
,, (white)	10·1	0·99	0·006	0·51	—
Average	*10·5*	*0·85*	*0·006*	*0·40*	Magnesium Per cent.
Rice (country)	13·2	0·91	0·02	0·39	0·06
,, (hill)	15·3	0·80	0·02	0·32	0·05
Green gram	9·3	3·7	0·17	0·38	0·19
Kurakkan	12·6	2·7	0·37	0·26	0·17
Wild breadfruit seed	7·8	2·2	0·07	0·29	—
Madu seed	11·0	1·9	0·07	0·18	Potassium Per cent.
Mature-coconut water	94·9	0·51	—	0·013	0·19
Young-coconut water	94·8	0·51	—	0·005	0·24
King coconut water	94·5	0·44	—	0·005	0·21

The following points in the tables call for comment :—

(1) *Adlay* compares favourably with dry grains in protein and fat, but its total mineral content is low. It is also low in fibre and is, in this respect, very similar to rice. Its phosphorus content (0·40 per cent.) is higher than that of kurakkan (0·26 per cent.) and rice (0·35 per cent.). It is, however, extremely deficient in calcium, being even more so than rice. Adlay is thus an unbalanced food so far as the essential minerals are concerned and cannot be used like kurakkan, which is rich in calcium, to supplement the deficiency of rice in this element. The three varieties of the grain are similar in composition, but the white variety appears to be of somewhat higher nutritive value than the other two.

(2) *Palmyra Root.*—Dried palmyra root, whether raw or parboiled, is mainly a carbohydrate food. Its protein, fat and calcium contents are low, but its supply of phosphorus is fair. There is but little analytical difference between the raw and parboiled products.

(3) *Cycas seed* (*Madu* S.) flour is relatively rich in protein but is mainly a carbohydrate food. It has a fairly high phosphorus content, but its calcium content is low. The flour is reported to contain certain toxic constituents which give it narcotic properties. It should not, therefore, be consumed regularly for any length of time, and when used for making food preparations is best mixed with two to three parts by weight of rice flour (6).

(4) *Yams, Tubers, &c.* are all starchy foods. They differ but little in analytical composition, but artichoke is relatively poorer in fat than the other samples examined. Yams are generally poor in calcium ; some of them, *viz.*, the colocasias and the alocasias (*desaiala* and *dehiala* S.) are rich in phosphorus. The iron contents of two samples of yams are low.

(5) *Oil Seeds, &c.*—The mineral analyses of gingelly indicate that it is a very good source of calcium, phosphorus and iron. This is a food crop the cultivation of which should be encouraged in Ceylon, for the reason that, in addition to being well supplied with the essential mineral constituents, it is rich in protein and fat (1). A minor food product of some interest, from the nutritive standpoint, is wild breadfruit (*wal del* S.) seed. Unlike jak, this seed is essentially an oilseed. It contains 34 per cent. of oil and 13 per cent. of protein and is fairly well supplied with phosphorus but is relatively poor in calcium.

Young-Coconut Water.—With a view to making the investigation on the nutritive values of local foods more complete, samples of king coconut (*tambili* S.) and young-coconut (*kurumba* S.) water were examined and compared with that of a mature coconut. Carbohydrates are the main constituents of the water of young coconut. Reducing sugars (3·95 and 3·46 per cent. respectively) amount, on the average, to over 85 per cent. of the total carbohydrates. Cane sugar is present only in small quantities (0·31 and 0·56 per cent.) In the water of mature coconut, the total carbohydrate content is lower (2·5 per cent. in one sample), but the sucrose content is relatively much higher (1·9 per cent.). Apparently, as the coconut matures, reducing sugars are converted into cane sugar. A similar observation has been made by Cochran (3).

SECTION II

In order to determine to what extent, if any, variations in the soil and climatic conditions under which vegetables are grown affect their mineral composition, samples of three leafy vegetables and three non-leafy vegetables were obtained from Colombo, the Jaffna Peninsula, and Kandy for determination of the mineral constituents, calcium, phosphorus, and iron. The Jaffna leafy vegetable samples were obtained from Tellippalai and Chunnakam and are indicated as (I) and (II) respectively in Table III which shows the complete results.

For Table III see page 341.

It will be noted from a study of this table that :

(i) In the case of the leafy vegetables, the Chunnakam samples are appreciably richer in calcium than the rest. The comparatively low calcium content of the Tellippalai samples is difficult to explain, as the soils of Chunnakam and Tellippalai are both derived from Miocene limestone and would be expected to be rich in lime. *Agathi* leaf appears to be richer in calcium than the other leafy vegetables. This was noted in the previous analyses also (4). The percentages of phosphorus in the leafy vegetables do not differ to any appreciable extent. Local leafy vegetables are rich in iron. Variations in their content of this element do not appear to be connected with the place of origin, but the Jaffna amaranth samples (*tampala* S.) are characteristic in being abnormally rich in this constituent. Repeated analytical determinations have confirmed this result. The only explanation that can be offered is that these samples were of a more tender age than those from Colombo and Kandy.

(ii) The non-leafy vegetables from Jaffna appear to be richer than the Colombo and Kandy samples in phosphorus and iron, but not in calcium. These vegetables have, on the whole, considerably lower calcium and iron contents than the leafy vegetables. "Ladies fingers" are richest and tomatoes poorest in calcium.

A comparison of the calcium and phosphorus percentages of local vegetables with those of corresponding Indian samples confirms what has been found previously (4, 5), *viz.*, that local vegetables compare unfavourably with Indian samples in regard to calcium and, to a lesser degree, phosphorus.

SUMMARY

Further analyses of samples of local foodstuffs with particular reference to their mineral composition and the variation of the latter with place of origin of the foodstuff, have shown that (i) yams, in general, are a poor source of calcium, but that the alocasias and colocasias are relatively well supplied with phosphorus ; (ii) gingelly is second only to the leafy vegetables as a

TABLE III

The Mineral Composition of Local Foodstuffs.

Name.	Botanical Name.	Sinhalese Name.	Tamil Name.	Place.	Moisture Per Cent.	Ash Per Cent.	Calcium Per Cent.	Phosphorus Per Cent.	Iron Mgm. Per Cent.
Leefy Vegetables—									
Drumstick	Moringa oleifera	Murunga	Murungai	Jaffna (1)	78·8	2·4	0·37	0·10	8·3
				,, (2)	77·9	3·1	0·64	0·09	9·6
				Average	*78·3*	*2·7*	*0·50*	*0·09*	*8·9*
				Colombo	78·6	2·9	0·35	0·09	10·7
				Kandy	77·1	2·2	0·39	0·08	5·2
				General average	*78·1*	*2·6*	*0·44*	*0·09*	*8·4*
Agathi	Seshania grandiflora	Kathuru-murunga	Agaththi	Jaffna (1)	78·9	2·0	0·38	0·10	5·3
				,, (2)	77·7	3·2	0·93	0·06	7·8
				Average	*78·3*	*2·6*	*0·66*	*0·08*	*6·5*
				Colombo	79·6	2·7	0·59	0·07	7·3
				Kandy	79·0	2·4	0·49	0·07	7·7
				General average	*78·8*	*2·6*	*0·59*	*0·07*	*7·0*
Amaranth (spp.)	Amarantus paniculatus	Tampala	Keerai	Jaffna (1)	89·7	2·9	0·26	0·10	32·6
				,, (2)	88·9	4·2	0·37	0·09	32·8
				Average	*89·3*	*3·6*	*0·34*	*0·09*	*32·7*
				Colombo	85·4	3·3	0·50	0·07	9·3
				Kandy	87·1	2·8	0·25	0·08	9·2
				General average	*87·8*	*3·3*	*0·34*	*0·08*	*20·9*
Other Vegetables—									
Brinjal	Solanum melongena	Battu	Kaththarikkai	Jaffna	92·8	0·70	0·02	0·07	1·1
				Colombo	91·6	0·71	0·01	0·03	0·5
				Kandy	92·3	0·62	0·01	0·035	0·6
Ladies fingers	Hibiscus esculentus	Bandakka	Vendikkai	Jaffna	90·8	0·84	0·07	0·09	1·8
				Colombo	92·9	0·62	0·06	0·045	0·7
				Kandy	89·4	0·86	0·07	0·05	1·3
Drumstick	Moringa oleifera	Murunga	Murungakai	Jaffna	87·1	0·97	0·02	0·11	1·5
				Colombo	86·4	0·76	0·03	0·03	1·1
				Kandy	88·2	0·94	0·02	0·05	0·5
Tomato	Lycopersicum esculentum	Takkali	Thakkali	Jaffna	93·6	0·78	0·01	0·06	1·2
				Kandy	94·6	0·66	0·004	0·02	0·5

rich source of calcium and iron ; its phosphorus content is also very high. Gingelly is a crop which should be extensively cultivated owing to its high nutritive value ; (iii) of the grains, kurakkan is richest in calcium, and adlay and rice in phosphorus. Adlay is extremely deficient in calcium ; (iv) there is some variation in the calcium content of leafy vegetables with place of growth. Soil conditions are apparently the determining factor ; (v) samples of young amaranth spp. (*tampala* S.) from Jaffna are very rich in iron ; (vi) of the minor food products, wild breadfruit seed, which has a composition similar to oilseeds, is a useful supplementary food ; (vii) young coconut water consists largely of reducing sugars. Potassium is its chief mineral constituent ; (viii) compared with Indian samples, Ceylon foodstuffs are generally poorer in calcium and, to a lesser degree, in phosphorus.

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FIG. 1.—LEAFLETS OF CARROT ATTACKED BY *Macrosporium carotae*

FIG. 2.—LEAVES OF CARROT PLANT ATTACKED BY *Macrosporium Carotae*

A BLIGHT OF CARROT LEAVES

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EARLY in October, 1939, a disease occurred in a bed of carrots, about 2 months old, in the writer's garden. At the time, the carrots were unusually fine and gave promise of an excellent crop. The disease spread rapidly through the bed and within three weeks it was impossible to find a single leaf unattacked; the great majority were dead. The petioles were yellow and drooping, and the leaflets brown and withered. So severe was the damage that it appeared advisable to uproot the whole bed. The roots were sound and there was no indication of injury or incipient decay.

A second bed about 20 feet away and planted at the same time remained healthy at first, but by the time the first bed was uprooted the second had become infected.

The first indication of the disease was the presence of small, brown spots on the lamina and at the edges of the leaflets of the older leaves (Figure 1). Surrounding the brown area usually is a yellow margin. The diseased areas rapidly increase in size until the whole leaflet is affected and dies. All leaflets are not attacked simultaneously; some leaves bear both healthy and diseased leaflets at the same time. Nor is the disease restricted to older leaves only (Figure 2). It spreads rapidly to all leaflets and to the petioles where it forms small, brown lesions. The older leaves wither first; the petioles become yellow and droop. Ultimately all leaves are affected and destroyed.

Associated with the disease was a species of *Macrosporium* with large brown clavate spores up to 12-septate, with 2 to 4 vertical walls, measuring 55–105 by 16–23 μ and having a long, tapering, hair-like appendage 118–175 by 1–2 μ.

A leaf disease of carrots caused by *Macrosporium carotae* has long been known in several states of the United States of America and South Australia. The spore measurements of *M. carotae* given by Saccardo are smaller than those from the Ceylon specimens, *viz.*, 55–70 by 12–14 μ with the "pedicel"

80–110 by 1·5–2 μ. Meier, Drechsler and Eddy (3), after examination of the type material as well as of fresh material collected in New Jersey and in Washington D.C., state that the spores may attain a length of 100 μ or more and a width of 30 μ and show from 9 to 11 transverse septa, with 2 or 3 longitudinal septa further dividing the transverse segments. They rightly point out that the "pedicel" of the original description is really an appendage or prolongation of the terminal cell of the spore. They state that the appendage may attain a length of 300 μ, bear 1 or 2 branches and have 1 to 10 septa although usually it is much shorter, without branches, and with but 3 or 4 septa. The amended description and figures given leave no doubt that the fungus from the Ceylon material is *Macrosporium carotae.*

In Massachusetts and Long Island (4) this disease is reported to cause severe damage and loss during exceptionally rainy summers. Doran and Guba (2) also record that abundant moisture is absolutely essential for the germination of the spores. The weather conditions during the later half of September and in October at St. Coombs* had been unusually wet, every day from 17th to 30th September being wet, and there were 25 wet days in October. In view of American experience, it is highly probable that these conditions strongly favoured the disease.

This is the first record of this disease in Ceylon and its origin is unknown, though the possibility of seed infection must not be overlooked. Thatcher (5) states that the spores of *M. carotae* are seedborne but Dolan and Guba (2) are of the opinion that the spores overwinter in the soil but are apparently not seedborne.

No control measures were attempted other than the removal of diseased plants in this instance, but a study of the literature indicates that this fungus is highly sensitive to the action of copper and that effective control can be obtained by the use of a copper fungicide such as Bordeaux mixture. In a field trial carried out in Ohio (1), a field planted late in April was sprayed with Bordeaux mixture (4–6–50) plus calcium caseinate (1 in 50) on June 15th when the plants were about 6 in. high, further applications being made at intervals of about 10 days on dates which happened to cover the period of heaviest summer rain. The field was harvested in September when it was found that spraying had increased the yield from 544 to 907 bushels per acre. The unsprayed plants were almost defoliated whereas the sprayed ones were tall, healthy, and green.

Spraying is not considered necessary against this disease in Ceylon except during very wet weather.

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* Talawakelle, Ceylon: Elevation—4,200 feet above sea-level.

SUMMARY

A blight of carrot leaves caused by the fungus *Macrosporium carotae* is recorded for the first time in Ceylon.

Spraying is unnecessary except in very wet weather when Bordeaux mixture (4–6–50) should give effective control.

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ANGRAECUM SESQUIPEDALE THOURS.

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THE genus of Orchid *Angraecum* is confined to Tropical Africa, its neighbouring islands, and some parts of the West Indies. *Angraecum sesquipedale*, which produces the largest flowers, is the most remarkable and beautiful plant of the genus and is peculiar to Madagascar.

Angraecum sesquipedale is an epiphyte of the monopodial type with an upright growth. The stem has two rows of dark-green, strap-shaped leaves gracefully arranged; these are closely set, divided into two and rounded at the tip.

The thick, fleshy roots arise from the lower region of the plant and occasionally from the axils of leaves.

The young leaves are faintly dusted with a thin coat of greyish powder. The flowers are larger than those of the other members of the genus and are borne on lateral racemes arising from leaf axils. In length they often exceed six inches across and are a pure ivory-white in colour. The three sepals and three petals overlap at the base and are pointed at the apex. But the hind petal—the labellum—is heart-shaped and broader than the other two. The column is extremely short and the rostellum is bi-lobed. The tail-like spur which arises at the base of the labellum is green and continues vertically downwards often as much as twelve inches. The flowers are fragrant and last for about three or four weeks.

Culture. Angraecum sesquipedale is a strong and hardy plant often reaching two to three feet in height and should be afforded all facilities for free development; though a small plant does not need a large receptacle for the start. A plant six to eight inches high may first be started in a six-inch pot and transferred later into a bigger one. For a well-grown plant, a perforated earthen pot or wooden tub is preferable to a cement or a metal one.

At the bottom of the pot should be arranged a layer of drainage material, *i.e.*, large bits of tiles or bricks, and then filled up with knobs of charcoal, small bits of brick, chips of hard wood or bits of old coconut husk. A well-grown specimen resents disturbance and should be grown in the same receptacle

ANGRAECUM SESQUIPEDALE THOUARS

as long as the plant does not show signs of deterioration. Fresh rooting material may be given occasionally especially after flowering is over. When the plant is well established, a position exposed to plenty of light is necessary for its healthy growth. It requires warm and moist atmospheric conditions, but reacts adversely to anything approaching stuffiness. Ample light and air rendering the atmosphere sweet and agreeable to the plant is necessary; stuffiness and a stagnant atmosphere often causes spots on the foliage, especially so when the plant is given regular watering during dull or moist weather.

Unless the plant becomes "leggy", with no leaves at the base of the stem, it is not advisable or necessary to disturb the roots frequently or to transfer the plant into another pot; the only thing required is to pick out some of the old compost and work in fresh compost. Moisture should be applied freely during the dry months.

EMERGENCY RUBBER COAGULANTS

(Communicated by the Rubber Research Scheme (Ceylon).)

THE following notes are issued in view of the prevailing shortage of formic and acetic acids among small users. It is recommended that proprietary coagulants of unknown composition should be avoided and that the prices at which coagulants are offered should be carefully scrutinized in relation to their coagulating power. For comparison it may be mentioned that the cost of coagulation with formic and acetic acids at the present controlled prices amounts to approximately 0·4 cents per pound of rubber.

ECONOMICAL USE OF COAGULANTS.

Under normal conditions it is recommended that the dose of acid used for coagulation should be such that a clear or only slightly cloudy serum remains. This dosage should not be exceeded and it may be justifiable under present circumstances to eke out supplies by reducing the quantity slightly. It should, however, be noted that the presence of a milky serum indicates that rubber is being lost.

Many small producers roll their rubber within a few hours of addition of acid to the latex. The amount can be reduced by approximately $\frac{1}{3}$ if the latex is allowed to coagulate overnight.

It has been suggested from Malaya that economy can be effected by re-using a proportion of the serum. Tests of this method are being carried out at Dartonfield but the results so far have been rather conflicting. In an initial trial moderately good coagulation was obtained when latex (previously diluted to a dry rubber content of $2\frac{1}{4}$ pounds per gallon) was treated with half its bulk of serum from the previous day's coagulation and the dose of acid was reduced to $\frac{2}{3}$ of the normal quantity. In a later trial under similar conditions coagulation was incomplete even when $\frac{3}{4}$ of the normal dose of acid was used but a further trial now in progress is giving satisfactory results with $\frac{2}{3}$ of the normal dose. It seems possible that the value of the method is affected by weather conditions. It can, however, be recommended for trial on estates.

ALTERNATIVE COAGULANTS

Sulphuric Acid.

Rubber manufacturers object to the use of sulphuric acid as a coagulant because the presence of an excess of acid in the rubber, which may easily occur under estate conditions, has an adverse effect on its vulcanizing properties. Nevertheless sulphuric acid can be regarded as a reasonably satisfactory emergency

coagulant and it is, in fact, the only alternative material which is likely to be obtainable in adequate quantities for estate use at short notice.

Concentrated sulphuric acid (oil of vitriol) is extremely dangerous to handle and should be diluted to half-strength before issue to estates and retailers. The half-strength acid should be diluted before use as a coagulant in the proportion of 1 part of acid to 80 parts of water. *Dilution should be effected by adding the acid slowly to the water and not by adding water to the acid.* Approximately ½ pint of diluted acid is required to coagulate a rubber sheet weighing 1½ pounds. (8 fluid oz. of half-strength acid in 4 gallons of water per 100 pounds of dry rubber).

The following points should be carefully noted when using sulphuric acid :—

1. The quantity used for coagulation should be as small as possible. A slightly cloudy serum should remain after coagulation.
2. The rubber must be thoroughly washed during and after milling to remove surplus acid. The latex should be diluted to a rubber content not exceeding 1½ lb. per gallon.
3. Machinery is liable to be damaged by the diluted acid unless thoroughly washed after use.

Half-strength sulphuric acid is at present being supplied by a leading importer at Rs. 2 per gallon (exclusive of the cost of carboys). One gallon should suffice for the coagulation of approximately 2,000 pounds of dry rubber.

Vinegar.

Vinegar is a useful emergency coagulant but it is not likely to be available in large quantities. Toddy vinegar contains approximately 5 per cent. of acetic acid and 1 gallon will coagulate approximately 100 lb. of dry rubber. It may be used undiluted for crepe manufacture but should be diluted with an equal quantity of water for sheet making. Approximately ¼ pint of diluted vinegar is required to coagulate a rubber sheet weighing 1½ pounds. Rice vinegar containing about 8 per cent. of acid is also available.

Coconut Water.

The milky fluid which occurs in the coconut ferments on standing and produces an acid liquor which can be used as an emergency coagulant. The maximum acidity, corresponding to about ½ per cent. acetic acid, develops in 3–4 days, after which a reduction of acidity takes place. This material and other plant extracts referred to in a later paragraph should be strained through clean cloth before use to remove any solid matter. Approximately one " bottle " (⅙ gallon) of the fluid is required to coagulate a rubber sheet weighing 1½ pounds.

Pyroligneous Acid.

Pyroligneous acid containing approximately 10 per cent. of acetic acid together with other products is obtained by the distillation of wood or similar material such as coconut shells. The practicability of preparing an improved material from coconut shells at an economic price is being investigated by the Coconut Research Scheme in conjunction with the Department of Industries but commercial supplies are not available at present.

Sugar.

When undiluted latex containing a small quantity of sugar is allowed to stand overnight the sugar ferments and moderately complete coagulation occurs. This form of coagulation does not produce first grade rubber; crepe is off-colour owing to the absence of sodium bisulphite and sheet is " bubbly ". However, the method may be useful, especially to smallholders, in case of a severe shortage of coagulants.

For the preparation of a rubber sheet weighing 1½ pounds, ¼ ounce of sugar (half match-box-full) dissolved in ¼ pint of water should be added to ½ gallon of undiluted latex. (One pound of sugar in 2 gallons of water per 100 pounds of dry rubber.)

Other Coagulants.

Lime juice contains 5–10 per cent. of citric acid and may prove useful as a coagulant for smallholders. The juice of 3–6 limes depending on ripeness and juciness, is required for the coagulation of a rubber sheet weighing 1½ pounds.

Various other plant juices and extracts are stated to be used by smallholders when normal coagulants are unobtainable or unduly expensive. *Goraka* fruits when extracted twice by boiling with water were found to have an acid content of approximately 10 per cent. The extract from 1 pound of semi-dried *goraka* fruits would thus suffice for the coagulation of 20 pounds of rubber. *Weera* and *kamaranga* fruits also yield acid extracts.

No great objection can be raised to the use of such products in an emergency but vinegar or coconut water are considered preferable.

Under the present exceptional conditions it may be necessary as a temporary measure for some producers to vary their normal methods of coagulation. *It is, however, very strongly urged that normal procedure should be resumed at the earliest possible moment with a view to maintaining the Island's reputation for producing good quality plantation rubber.*

Research Laboratories,
Dartonfield,
Agalawatta,
December 7th, 1939.

DEPARTMENTAL NOTES

NOTES ON THE CULTIVATION OF FOOD CROPS

THE campaign for increasing food production in Ceylon has led, in many areas, to the planting or the preparation of land for the planting of crops which are strange to the growers. The Department of Agriculture is publishing a series of simple leaflets giving a brief outline of the methods of cultivation of crops, the growth of which is recommended by the Director of Food Production. To give wider publicity to this information, the notes on the cultivation of eight of these crops are reproduced below.

KURAKKAN (*ELEUSINE CORACANA*)

Kurakkan is an important millet grown chiefly in chenas in the dry zone areas of Ceylon. It is rich in calcium, iron, and vitamin A in comparison with other cereals and could profitably replace rice in three or four meals a week.

Climate and elevation.—Although best grown in the dry zone areas of the Island, kurakkan does well elsewhere up to an elevation of about 4,000 feet under moderate rainfall conditions.

Type of land.—The crop is usually grown in chenas in the first and second years after clearing and burning the jungle. It can, however, be grown in any type of highland, including the upland hill slopes, provided the soil is a well-drained loam, fairly rich in organic matter. It will not be successful on eroded patnas, *kekilla* lands, gravelly or sandy soils, unless heavily manured with cattle manure at the rate of 15 to 20 cartloads per acre.

Season and method of cultivation.—The north-east monsoon is the more favourable season in all parts of the Island, except the Jaffna Peninsula, where this crop is planted at different times during the dry season from February to September, and grown under irrigation.

The seed is sown broadcast at the rate of 4 measures (8 lb.) per acre and, after sowing, it should be lightly covered over with soil by means of mammoties or the tooth harrow.

When the crop is grown under irrigation, the seed should be raised in nurseries, about 6 lb. of seed being sown on $\frac{1}{8}$th acre which will provide sufficient seedlings for transplanting an acre. When the seedlings are about 25 to 30 days old, they

should be transplanted at 3 in. to 4 in. apart, one seedling per hill. Irrigation should be withheld or restricted for about 10 to 14 days until the seedlings have established themselves. Thereafter, the crop should be irrigated at about four-day intervals. The crop will benefit by weeding at least twice.

Age and yields.—It takes about 3 to 4 months for the crop to be ready for harvesting, the broadcast seed ripening about 3 to 4 weeks earlier than the transplanted seed. Ripening is uneven and harvesting of earheads should therefore be done on two occasions, the second after an interval of about 10 days. There are several varieties, some being early maturing (3 months) and others late maturing (4 months).

The average yield is about 15 bushels per acre under chena conditions, though as much as 25 bushels per acre may be obtained under favourable conditions. Under irrigation in Jaffna the average yield is about 40 bushels per acre.

Storage and use.—The earheads should be dried in the sun for two or three hours each day until they are thoroughly dry. They should then be stacked in a dry shed with a free circulation of air. The storage of kurakkan does not offer much difficulty as it is not very subject to attack by insects or moulds.

The earheads should be threshed as grain is required. Threshing is easily carried out by means of the village mortar and pestle. Milling is done by means of the kurakkan hand mill, and the percentage of grain after milling is about 95.

Seed.—A pure-line strain of kurakkan, known as E 43, has been evolved by the Department of Agriculture. The age of this strain is 3½ months and its use is recommended.

Bushel weight.—60 lb.

ADLAY (*COIX LACHRYMA—JOBI*)

Adlay or Job's tears, sometimes erroneously referred to as barley by the villager in Ceylon, is a cereal which is a good substitute for rice in the various preparations which can be made from it and which closely resemble those made from rice.

Climate and elevation.—The crop can be grown in the wet zone, provided a dry period prevails when the ears set, and in certain parts of the dry zone such as North Matale. It will grow at all elevations up to about 4,000 feet.

Type of land.—Adlay can be cultivated in chenas, abandoned *owita* lands and all high lands. It requires a well-drained soil. It will not be successful on eroded patnas, *kekilla* lands or gravelly soils, unless these are manured with compost or organic manure at the rate of 15 cartloads per acre.

Season and method of planting.—Planting may be done during the north-east monsoon in the dry zone and during both monsoons in the wet zone.

The seed should be sown in rows 2 feet apart and 2 feet apart within the rows, 3 to 4 seeds being placed in each hill. The seed rate is 8 lb. per acre. When the seedlings are about 6 inches high, they are thinned out leaving two per hill. Adlay can also be transplanted in the wet zone areas and any seedlings removed during thinning out can be transplanted on new land or used for filling vacancies. The crop should be weeded on two or three occasions until tillering commences.

Adlay responds well to liberal applications of organic manure. In the dry zone areas, irrigation should result in increased yields.

Age and yields.—The period of ripening varies from four months in the dry zone to about five in the wet zone. A second or ratoon crop can be obtained if there is wet weather following the harvest, but this is not generally profitable unless the plants have tillered well. In harvesting, the whole plant should be cut down as low as possible but, owing to uneven ripening, the crop should be harvested on two occasions.

Threshing is done by beating the sheaves against a post or log or by trampling.

Yields vary from 40 to 50 bushels of unhusked grain, but as the milling outturn is only about 30 per cent., the outturn of edible grain will not be more than about 10 to 15 bushels. Under favourable conditions, however, yields of about 75 bushels of unhusked grain have been obtained.

Storage and use.—If the seed is to be kept successfully, it must be well dried. The seed should be dried in the sun for two or three hours a day, not more, until thoroughly dry. The exposure of seed to the sun for long periods at a time is not recommended.

Adlay kept for seed should not be husked and, as it is liable to be attacked by weevil, it should be kept in the roof of a house where it will be exposed to smoke from the fire. Alternatively, it should be stored in air-tight bins and should be examined periodically. If weevils are seen the seed should be dried again and, if possible, fumigated.

If it is desired to store large quantities of adlay for consumption, the seed should be husked, the grain dried in the sun and stored in air-tight bins or in large clay pots. A few dried margosa leaves and a sprinkling of ashes on the top of the grain will help to keep away insects.

The local village mortar and pestle as used for hulling paddy can be used for extracting the grain.

Bushel weight.—35 lb.

2——J. N. 90023 (11/39)

MAIZE OR INDIAN CORN (*ZEA MAYS*): **S.** *BADA-IRINGU.*

Although the second most important cereal crop in the world, maize is only casually grown in Ceylon, being confined chiefly to chenas as a mixed crop and to small plots in peasant holdings. To those who are accustomed to rice, maize is somewhat difficult to digest at first but, if taken in gradually increasing quantities, it will be found to be a valuable substitute for rice. From the nutritive point of view, its protein and mineral value is as high as country rice, while it has a higher fat content. Many useful preparations can be made from maize but they require twice as long to cook as rice.

Climate and elevation.—Maize is suited to localities where a certain amount of dry weather can be depended upon at the time of harvest, as the cobs should be thoroughly dry for storage purposes. It grows best in the cooler regions of the dry zone in Ceylon, but it can be successfully raised elsewhere up to an elevation of about 4,000 feet provided the rainfall is not too heavy during its cropping period.

Type of land.—Maize is, generally, grown in chenas as a mixed broadcast crop with kurakkan. It is also cultivated on any type of high land including the upland hill slopes. The best soil is a sandy loam, clay or ill-drained soils being unsuitable. Maize will grow on soils which are not rich enough in organic matter for kurakkan. Maize does not do well in the Jaffna Peninsula and Pata Hewaheta Division of the Kandy District.

Season and method of planting.—The crop should be grown during the north-east monsoon, so that the crops reach maturity during the dry months of January and February.

The seed should be sown, 1 to 2 inches deep in rows, 3 feet apart, and 1 foot apart within the rows. The seed rate is about 12 lb. per acre, about four seeds being placed in each hill. Cowpeas may be interplanted between the rows of maize and will prove a useful leguminous mixture. When the seedlings are about 8 inches high, they should be thinned out to two plants per hill. About two weedings should be done before the cobs begin to develop. The suckers should be nipped off.

Age and yields.—The crop ripens in about 100 to 120 days. In harvesting, the cobs should be snapped off the stems. Yields vary from 4,000 to 8,000 cobs per acre depending on the conditions of soil and climate, and when dried, will weigh from 1,250 to 2,500 lb. On shelling, a yield of 1,000 to 2,000 lb. of grain per acre should be obtained.

Storage.—Maize, when stored, is very subject to weevil attack and great care is necessary if wastage is to be avoided. After harvesting, the sheaths surrounding the cobs should all be

removed except the innermost ones. The cobs must be thoroughly dried by exposure to the sun for two or three hours a day for a number of days.

The best way to store the cobs is to tie them together in pairs and to hang them over rafters in a barn. If they can be exposed to smoke once or twice a week insect attack will be avoided. In villagers' houses the cobs reserved for seed should therefore be hung in the roof where they will receive some of the smoke from the fire.

The storage for consumption of large quantities of maize is difficult if damage is to be avoided. The grains should be removed from the cobs and dried again. The secret of successful storage is to ensure that the grains are thoroughly dry. The grains should then be stored in bins with close-fitting lids or in earthenware pots. The stock should be inspected periodically and, if weevil injury is seen, the grain should be fumigated or, if that is not practicable, spread out in the sun and picked over to remove infested grains before storing again.

Bushel weight.—60 lb. dry corn in the cob up to 70 lb. (30 lb. to a cubic foot).

CUMBU (*PENNISETUM TYPHOIDEUM*)—THE BULLRUSH OR PEARL MILLET

This cereal which is known as *bajri* in North India, and *cumbu* in South India, is one of the most important millets grown in India and Tropical Africa. There are millions of acres under this crop in India. It is of high nutritive value, being richer in protein and fats than any other tropical cereal and in mineral salts than rice and maize.

Climate and elevation.—*Cumbu* is essentially a dry zone crop and can be raised in areas of low rainfall where all other cereals are unlikely to succeed. Once the seed has germinated, it will grow with very little rain. It can, however, be grown successfully in the mid-country zones during the north-east monsoon. It will not do well at elevations above 3,000 feet.

Type of land.—The crop can be grown on chenas in the dry zone and in highland on all but the heavier types of soil. It can also be cultivated during the *yala* season on certain paddy lands under village tanks where the soil is light-textured and well-drained, when there is insufficient water for growing paddy.

Season and method of planting.—In the dry zone, *cumbu* is an ideal cereal for the south-west monsoon season and should be grown in rotation with other crops.

In the moderately wet mid-country zones, it may be grown during the north-east monsoon, so that the crop may ripen during the drier months of January and February.

The seed is sown about 1 inch deep in rows 1½ feet apart and 1 foot within the row at the rate of 6 lb. per acre, and after sowing, it should be lightly covered over with soil by means of mammoties or the spiked harrow.

The crop may be weeded once followed by an earthing up.

Age and yields.—The crop ripens in about 3½ to 4 months, but as ripening is uneven, as in the case of kurakkan, harvesting should be done on two occasions at an interval of about 10 days. There is an acclimatized variety from India called Jamnagar, which is being successfully grown at the Experiment Station, Peradeniya, and takes about 4 months to mature. The ripening seed is subject to attack by paddy birds and care should be taken to scare these away. The earheads should be cut and, after heaping indoors covered with straw for 2 to 3 days, the grain may be threshed as in the case of kurakkan.

The average yield is about 15 bushels per acre, although under good conditions about 25 bushels per acre may be obtained.

Storage and use.—The seed, if well dried, will keep for long periods. It can either be stacked in the ear in a dry barn or it can be threshed and stored in earthenware pots or bins. A layer of margosa leaves and a sprinkling of wood ash on top of grain stored in pots or bins will assist in keeping away insect pests.

Milling of *cumbu* can be done on the kurakkan hand-grinding stone.

Bushel weight.—50 lb.

SORGHUM (*ANDROPOGON SORGHUM*), S. *KARAL IRINGU*

This cereal is the staple food of a quarter of the world's population and, although not usually grown in Ceylon, it has considerable value as a grain crop.

Climate and elevation.—Sorghum is generally suitable for a dry area where maize will not grow and it is capable of standing severe droughts. At harvest time it is susceptible to damp weather.

Type of land.—The plant will grow and produce a crop in nearly every soil, but the one best suited to it is a rich light sandy, well-drained and not too moist soil. It may be grown up to an elevation of about 4,000 feet.

Season and method of planting.—The seed rate is about 10 lb. per acre. The seed should be sown about 1 inch deep in rows 1½ feet wide and 1 foot within the rows. When the seedlings are about 8 inches high, they should be thinned out to two plants per hill. The crop may be weeded once followed by an earthing up.

Age and yields.—The grain sorghums vary in age from $3\frac{1}{2}$ to 7 months, depending on the variety. There is an acclimatized variety from India called Budhperiô, which has grown successfully at the Experiment Station, Peradeniya, and takes about 4 months to mature. It is a white-seeded variety with a compact drooping head. The ripening seed is subject to bird attack and care should be taken to scare birds away.

Harvesting is done by cutting off the ears, which are kept in heaps for a few days. A ratoon crop should not be allowed as the sprouting plants after the first harvest are likely to contain prussic acid which is poisonous.

The average yield is about 20 bushels per acre (1,500 lb. per acre), though with irrigation and good manuring, about 30 to 40 bushels may be expected.

Storage and use.—The earheads should be threshed and the grain dried by exposing it to the sun for two or three hours a day for several days until it is perfectly dry. If the seed is not dried thoroughly it develops moulds and is very subject to insect attack.

The dry grain may be stored in earthenware pots or bins with tight-fitting lids. A layer of margosa leaves and a sprinkling of wood ashes on the top of the grain will help to keep insects away.

Sorghum can be ground and cooked to a rough meal or it can be cooked as whole grains like rice.

Bushel weight.—56 lb.

THE SOYBEAN

The soybean or soya is a valuable food crop because the seed, which can be cooked in a variety of ways, contains the vitamins A, B, and D and sprouted seedlings contain vitamin C in addition. It is very rich in protein (40 per cent.) and in fat (17 per cent.) and is particularly rich in calcium.

Climate and elevation.—The crop will grow well in the dry zone and in moderately wet regions provided there is sufficient dry weather for the pods to mature and dry. At high elevations of about 5,000 feet and over, growth and production of seed may not be satisfactory.

Type of land.—A medium loam on any high land including the upland hill slopes is most suitable. It will not grow well on eroded patnas or gravelly soils, unless heavily manured.

Season and method of planting.—It should be grown during the north-east monsoon, although in the Jaffna Peninsula it can be successfully raised under irrigation during the dry season from March to September.

The seed should be inoculated with the nodule-forming bacteria, if it is being grown for the first time on the land, and

the soil is also not well manured with compost, cattle manure or other nitrogenous fertilizer.

The system of growing soya for two or three successive seasons on the same land will result in increasing crop yields, year by year.

As lime stimulates growth, especially if the soil is acid, an application of about 5 cwt. to 1 ton per acre of air-slaked lime, depending on the acidity, about 2 to 3 weeks before sowing will be useful. An application of basic slag at the rate of 1 cwt. per acre (in the rows) a few days before planting is also of advantage. The slag should be mixed with 2 or 3 times its weight of dry soil and then spread in the rows.

There are three types of seed—large, medium, and small—and the seed rates and spacings should be as follows, the seed being planted not more than 1 inch deep one seed per hill in drills :—

	Spacing.	Seed rate lb.
Large seed	1 ft. by 3 in.	90
Medium seed	2 ft. by 3 in. (good soil)	20
	1½ ft. by 3 in. (poor soil)	25
Small seed	as for medium	20

In the dry zone, when the crop is grown during the months of March to September, irrigation is of great benefit.

Age and yields.—The age of the crop is about 3 to 5 months depending on the type. The large seed varieties generally mature in 3 to 3½ months and the smaller seed varieties in 4 to 5½ months. When the pods turn brown, they should be harvested and dried in the sun, before extracting the seed.

The large seed varieties are most palatable, though less prolific than the medium and small seed varieties. The small seed varieties are twining plants and are best grown as green manures.

Storage.—The seed should be well dried by exposure to the sun for two or three hours a day (not more) for several days until it is thoroughly dry.

The storing of soybeans in air-tight bins is not recommended as it is reported that, after a time, the oil in them becomes rancid and this spoils them for consumption or for seed purposes. They should therefore be *thoroughly* well dried and stored in sacks or open bins covered with sacks.

Bushel weight.—40 to 60 lb.

DHAL (*CAJANUS CAJAN.*)

Dhal (red gram) or *parippu* is the chief pulse crop imported into Ceylon. It contains about 22 per cent. protein and is fairly rich in vitamin A and vitamin C. One of the best varieties is that grown in Gujerat.

Climate and elevation.—The crop produces seed most prolifically in the dry zone. It is remarkably drought-resistant. It grows well up to an elevation of about 2,000 feet, but above this up to 3,500 feet its growth is slow and maturity delayed.

Type of land.—Dhal thrives in almost all types of soil varying from sand to heavy clay loams but it is best cultivated in a medium heavy loam that is well drained.

Season and method of planting.—It may be sown as a mixture with crops of shorter duration such as kurakkan, maize, cumbu, &c., which are harvested later. In this form of mixture, the dhal may be sown in widely spaced rows varying from 4 to 8 feet apart depending on the type of its associated crop and the spacing given to it. The seed rate with this type of mixture varies from 1½ to 3 lb. per acre.

As a pure crop, dhal should be planted in rows 3 feet apart and 2 feet apart within the row, about 3 to 4 seeds being placed in each hill. The seed rate is 8 lb. per acre. When the seedlings are about 8 inches high, they may be thinned out to 2 plants per hill.

The seed should be sown as early as possible in October, with the commencement of the north-east monsoon rains.

Age and yields.—If planted in October, the annual varieties such as Gujerat which is recommended for cultivation in Ceylon would flower in January and yield a first crop in March. The second flowering starts early in June and the second which is also the final crop can be removed in August or early in September.

About two weedings should suffice. As a mixture, the yields vary from about 300 to 600 lb. per acre depending on the type of mixture. As a pure crop, yields from 800 to 1,000 lb. per acre may be obtained.

Harvesting.—In harvesting the first crop, it is necessary to pick the beans by hand. For the second crop, the plants should be cut down to ground level and threshed at convenient centres.

Storage and use.—For consumption the seed coat is removed and the seed split into halves and dried. The method of manufacture to obtain the best results has been described elsewhere. Further information on this can be obtained from the local Agricultural Officer. In the manufactured form the storage of dhal offers no difficulties.

Seed which is reserved for sowing needs careful attention as it is subject to weevil injury. First, it should be thoroughly dried by exposure to the sun for two or three hours a day for several days until it is quite dry. It may then be stored in a sack which is placed in the roof of a house where it is exposed to smoke from the fire. Alternatively, the dried seed may be

stored in an earthenware pot. On top of the seed should be placed a layer of margosa leaves and a sprinkling of ashes. Another method is to cover the seed in the pot with a layer 1 to 2 inches deep of dry sand. Weevils present in the seeds will make their way to the surface through the sand and will be unable to return through the sand.

Bushel weight (of seeds).—56 lb.

DRY CHILLIES

There are about 180,000 cwt. of dry chillies, valued at about Rs. 26,000, annually imported into Ceylon. The most important commercial types are those known as Tuticorin, Calcutta and Singapore, named after the ports from which they are shipped. Of these the long Tuticorin variety, grown in the Tinnevelly district of South India, commands the highest value owing to its bright red colour, a smooth glossy skin, a firm stalk which does not easily become separated during storage, and a high degree of pungency as well as a good flavour. This is the variety which is recommended for cultivation in Ceylon.

Climate and elevation.—Dry chillies can be best produced in the dry zone areas, but in moderately wet regions they may be grown provided there is sufficient dry weather for the pods to ripen and be dried in the sun.

Type of land.—Chillies can be grown on chenas and any type of high land. A medium loam soil is best.

Season and method of planting.—The crop should be grown during the north-east monsoon season. In the Wiraketiya area of the Southern Province, dry chillies can also be cultivated during the south-west monsoon season.

(*a*) *Preparation of the nurseries.*—The seed is best sown in nurseries at the rate of ½ lb. per 360 sq. ft., which will provide sufficient seedlings for transplating one acre, provided the seed is of good germination. Four beds each 30 feet by 3 feet wide should be made and a dressing of compost or finely-powdered cattle manure at the rate of 2 lb. per sq. ft., should be added. On each bed 2 oz. of seed should be sown broadcast or in rows 1 inch apart. The edges of the beds should be raised slightly to prevent soil wash. The seed should be sown about ¼ inch deep. The beds should then be watered and covered over with straw or cadjan. After about a week, the covering should be removed.

When the seedlings are about a fortnight old, they will benefit considerably by being watered with a solution of sulphate of ammonia at the rate of 1 oz.

per gallon of water used over 50 sq. ft. of nursery. The dose should be repeated a week later. The seedlings should be transplanted when they are about 4 weeks old, the first flowers appearing at this time.

(*b*) *Planting out.*—This is best done in the cool of the evening. The seedlings should be topped and then planted out with a pointed stick, 2 seedlings being placed in each hill. The spacing should be 3 feet between rows and 3 feet within the rows. After planting each pair of seedlings, the soil should be pressed around but not too closely against the collars of the seedlings and over the surface a little dry soil should be sprinkled. If the season is very wet during the active growing period of the crop, planting should be done on ridges about 9 inches high.

(*c*) *Intercultivation.*—The first weeding should be fairly deep and should be given about 7 to 10 days after planting out. The second, about a fortnight later, at the same time that the fertilizers are applied and this should be followed by an earthing up. The third weeding should be about 3 weeks later and should be fairly shallow.

(*d*) *Manuring.*—The field should receive an application of compost at the rate of 3 tons per acre, and an application of sulphate of ammonia at 1 cwt. per acre, 3 weeks after planting out.

Age and yields.—Tuticorin chillies generally come into flower about one month after planting out and picking of green but well-developed fruits commences about 2½ to 3 months after planting out, and of ripe fruits about a fortnight later. The first picking, however, should be of mature green fruits and the subsequent pickings of red ripe fruits.

In drying the red ripe fruits, they should first be heaped indoors for about 2 days, so that a deep red colour may be developed. The heaps should then be sorted for discoloured or diseased fruits, and the clean fruits then be spread on a drying floor and exposed to the sun for about 4 to 6 days depending on the intensity of the sun. On the morning of the second and third days the pods should be trampled on or rolled over so that they become flattened, a desirable condition for marketing.

The average yield of dry chillies is about 800 lb. per acre although with good cultivation and manuring yields up to 2,000 lb. per acre have been obtained.

Storage and use.—The well-dried pods should be stored in gunny bags. Owing to the higher pungency of Tuticorin chillies a smaller quantity of pods should be used for flavouring purposes in comparison with other varieties of dry chillies, with the exception of the Bird pepper.

ADLAY AS A WEED OF PADDY FIELDS

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AND

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ADLAY is the common name of a grass, *Coix lachryma—Jobi* L., which produces edible seeds ; it is also called Job's tears, presumably from the shape of the seeds. It is fairly extensively cultivated, though not intensively, except perhaps in the Philippines, where it was popularized by the Department of Agriculture ; elsewhere it is grown as an auxiliary foodcrop, or it may be grown in place of rice in seasons when successful paddy cultivation is uncertain.

Adlay is a fairly recent introduction to Ceylon, but there is an indigenous species of Coix, *C. gigantea* Koen., which occurs fairly commonly in and near paddy fields in the Kurunegala, Ambepussa, and Veyangoda districts, but which shows no sign of being a pest. The cultivated species is occasionally found growing among other crops, and, when its cultivation was undertaken experimentally by the department, fears were expressed that it might be a potential danger as a weed, particularly in paddy fields. Accordingly, experiments were devised to measure the degree of possibility of its becoming a pest.

Two plots on the paddy area of the Experiment Station, Peradeniya, were sown according to the following planting programme. Both plots were sown twice a year with paddy. In one, adlay was introduced in the *maha* season, by mixing seed of adlay with the paddy seed before sowing the plot ; in the other, the adlay was introduced in the *yala* season by the same method. Each plot was divided into two equal parts ; in one, the adlay seed was introduced with the paddy in the first season only; and thereafter the plot was sown with pure paddy, and in the other adlay was reintroduced every *maha* or *yala* season, as the case may be. Whenever adlay was sown with the paddy, the mixture

was in the proportion of one pound adlay to 4 pounds paddy, *i.e.*, 20 per cent. adlay. This planting programme was designed to cover all possibilities; for example, adlay may mature in the same period of time as either but not both the varieties of paddy grown during the two seasons, and it should, therefore, be introduced in either season; it may be harvested with the paddy or it may drop its seed before the paddy is ripe—sowing it only once will tell us what happens in those fields where the cultivator is careful to winnow his seed before sowing it and where the danger comes only from seed that has been shed. Sowing it repeatedly will tell us what is the result of taking no precautions to clean the paddy used for sowing, and thereby running the risk of reintroducing weed seeds. The proportion of adlay seed is perhaps high in this last treatment, but it could be modified subsequently if necessary.

At harvest, the whole plot was harvested together, and the adlay seed was winnowed out and weighed. The results are given in tabular form in the table accompanying this note, where the figures show the percentage by weight of adlay in the paddy crop.

It is quite clear that there is no danger from adlay as a weed of paddy fields, at least under Peradeniya conditions. The *yala* figures are not satisfactory, because it so happened that the plots used for this experiment were the only ones cultivated for the *yala* season in the block of paddy fields in which they stood, and in consequence of the attack of birds, field mice, and paddy flies yields were very poor. Nevertheless, conditions were normal during the *maha* season, and the results from the two seasons are essentially similar.

In all seasons, the growth of the adlay was slower than that of the paddy; measurements of height were made at monthly intervals, and showed that the adlay plants were always a half to two-thirds of the height of the paddy plants. They were easily distinguished from the paddy by their broader leaves and lighter colour. In the *maha* season, the adlay flowered first, taking an average of 113 days against the 135 of the paddy; the plots were harvested when the paddy was mature, but no great amount of adlay seed appears to have been shed; at any rate, no plants appeared in the interval between the two seasons, nor when the fields were flooded in preparation for the next season's cultivation. In the *yala* season, the adlay flowered later than the paddy, requiring 136 days against the 102 of the paddy, and when the paddy was harvested, the adlay seeds were still immature. Indeed, many of the adlay plants had not even flowered at the time of harvest.

SUMMARY OF RESULTS.

Season	Adlay sown during *maha* Season (Plot 1).				Adlay sown during *yala* Season (Plot 2).			
	Adlay sown once only (A)		Adlay sown each year (B)		Adlay sown once only (A)		Adlay sown each year (B)	
	Treatment	%	Treatment	%	Treatment	%	Treatment	%
Maha 1937–38.	Mawi and Adlay	0·045	Mawi and Adlay	0·045	Mawi only	—	Mawi only	—
Yala 1938 ..	Heenati only	0·	Heenati only	0·	Heenati and Adlay	0·585	Heenati and Adlay	0·
Maha 1938–39.	Mawi only	0·	Mawi and Adlay	0·009	Mawi only	0·	Mawi only	0·
Yala 1939 ..	Heenati only	0·	Heenati only	0·	Heenati only	0·	Heenati and Adlay	0·

SEASONAL PLANTING NOTES

CALENDAR OF WORK FOR FEBRUARY

T. H. PARSONS, F.L.S., F.R.H.S.

THE month of February is usually one of dry conditions, particularly in the south-west parts of the Island, and any planting or seed-sowing should be done only if a good supply of pipe, tank or well water is available.

Where such a supply of water is available, successions of annual flower seeds can be raised as can, also, the quicker-growing vegetables, for the nights are cool and the mornings heavy with dew. It will be wise, however, when contemplating such sowings to soak the bed well overnight ready for sowing the next morning, and the use of a few cadjans or a layer of straw over the bed surface till the seedlings appear through the ground is recommended.

There is no question of the fact that a good garden soil is one that possesses good "body". On estates and on farms chemical manures are generally used in quantity, but mostly from necessity also. These chemicals, used liberally, produce and create good yields but they do not assist in increasing soil fertility. For this purpose farmyard manure and other forms of humus are required, and it is here that lawn mowings come in useful. Compost pits, where all lawn mowings, leaves, sweepings, and in fact anything in the way of garden waste (except hard wood stuff) can be stored and treated are a necessity in any garden.

There are many methods of composting and for those that have time to practise and supervise it the Indore process is probably the best, but the Adco method also gives satisfactory results.

The general and common garden method is, however, to spread out all garden refuse, which has been collected, into a layer of about a foot thick, and cover with a 2-inch layer of lawn mowings. The heap should then be dressed with a dusting of calcium cyanamide or sulphate of ammonia at half an ounce to a square yard over which should be sprinkled a thin layer of wood ash and of soil. Repeat again, making the refuse heap 2 feet high. This should then be well trodden down and

periodically watered, but those possessing a cattle shed in the vicinity can with advantage utilize the urine and floor washings instead.

The heap should be turned and re-stacked after 15 days, and again after a period of 20 days when the material should be left for another month to mature fully.

Indications are given in the previous months' calendars as to varieties of vegetables to grow and those calendars should be consulted. Most people now know that, from the point of view of nutrition, a combination of cereals and legumes is strongly to be recommended, but much advantage is gained by variety in diet. In the first report—Part I of the Committee of Nutrition in the Colonial Empire—published recently it states "where a diet is (as in this country) and may have to remain predominantly vegetarian the chief deficiency may well be in calcium, and among the plant products green leafy vegetables alone furnish a satisfactory means of repairing this deficiency". Also "an important point in regard to the value of green leafy vegetables as a source of food is their perishable nature. Experiment has confirmed that with wilting and injury such as occur in storage and transit there is a marked and growing loss of vitamin C and the precursor of vitamin A. It is therefore desirable that this class of vegetable should be eaten wherever possible shortly after removal from the ground".

The leafy vegetables referred to would include spinach, lettuce, cabbage, cauliflower, kales, amaranthus, and colocasias among others. Lettuce, however, takes first place as it can be eaten uncooked. The loss of vitamins that occur when vegetables wilt or have to be stored, makes it the more important that as large a proportion as possible of foodstuffs should be grown by the people who consume them.

Among seasonal operations, in the north and east the paddy crops will be ripening, and there is yet time to sow dry grain such as gingelly, kurakkan, peas, and kollu as soon as the main crops are harvested. Tobacco plantings need careful attention, and also water at this time.

In other parts of the Island, some attention should now be given to conserving moisture in the soil for if the dry spell has not already commenced, it will do so soon. Beds and borders, therefore, should be weeded, the surface stirred and some form of mulch applied, and in this respect grass mowings serve a very useful purpose. Should the drought season have arrived, systematic watering will become necessary but in watering a great point to remember is that any bed, border, or even a pot plant that is watered, should be given an ample supply. It is much better for the plant if the soil is well soaked at

intervals of several days rather than if a small sprinkling of water is made daily. In the former case, the roots and rootlets get down into the soil where the moisture is, whilst in the latter, light watering only moistens the surface of the soil and the rootlets are brought to the surface with consequent damage to them as the moisture dries out rapidly during the hot hours of the day.

SELECTED ARTICLES

DEVELOPMENT OF MODERN COMPOSTING METHODS*

THE deliberate use of rotted organic wastes—vegetable and animal—for the purpose of growing larger quantities of better crops seems to be as old as the art of agriculture itself. It is conceivable that primitive man may have simultaneously (1) noticed the superiority of natural vegetation growing in virgin forest land rich in organic matter, and (2) discovered the possibility of artificial cultivation of some of the plant species suitable for his food.

At any rate, the importance of farmyard manure to crop growth has been stressed in ancient Indian and European literature on agriculture (Russell and Richards, 1917). King (1926) has described in detail how the Chinese peasants of old took elaborate care to collect all available wastes and convert them systematically into well-rotted composts. It is noteworthy that in every part of the world this system of returning its own waste material to land has maintained soil fertility in spite of continuous cropping through the ages. The crowded population of China is still being maintained on the produce of its soil after its agricultural use for over forty centuries. This is perhaps the most convincing proof of the perfect balance of ancient systems of agriculture with their environment. It is very striking, indeed, that modern composting technique has very little to add to the basic principles underlying the Chinese method of making manure from agricultural wastes.

Liebig published in 1840 his essay "Chemistry in its Application to Agriculture and Physiology". This marked the beginning of a period when scientific investigations and commercial enterprise concentrated on the stimulation of crop production by means of factory-made chemical manure. Subsequent work at Rothamsted and elsewhere established the manufacture of artificial fertilizers on a sound footing. Factories engaged during the war in the fixation of atmospheric nitrogen needed new markets afterwards. This further intensified the use of chemical manures. The use of bulky farm manures fell into the background. It was even asserted that this practice was not an essential feature of agriculture. A school of scientific workers, however, soon arose who maintained that a certain proportion of humus is essential to preserve the crumb structure in soils and that such a structure in turn was essential for efficient plant growth (Russell, 1934; Symposium on Soil Organic Matter, 1927).

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* By Y. D. Wad of the Institute of Plant Industry, Indore, Central India, in *Agriculture and Live-stock in India*, Vol. IX., Part V., September, 1939.

Another group of scientists (Howard, 1937, 2) believed that the artificial stimulation of soil activities for commercial cropping was sure to upset the natural balance of soil factors and in the long run might lead to evils not yet fully realized. They maintain, therefore, that in any agricultural system adequate provision is absolutely necessary for returning all the waste products of agriculture back to the land. Howard (1937, 1) even maintains that in specialized systems such as the planting industries it may be necessary to make provision for the supply of humus to the soil by manufacturing it at extra cost from other sources to enable the soil to meet the abnormal strain resulting from highly intensive cultural practices.

Also, the large majority of the cultivators in the world still believe that the produce obtained by the use of chemical manures is not always equal in quality to that obtained by the use of ordinary farm manure.

Recent discoveries of workers on animal nutrition have apparently confirmed this belief by their findings (McCarrison, 1926, 1937 ; Viswanath and Suryanarayana, 1927 ; Ramiah, 1933). It has also been claimed (Howard, 1937, 1) that the use of humic manures from vegetable and animal wastes imparts disease resistance both to crops and the animals that feed on them. Recently, a fresh impetus was received by the investigations into the nature of soil humus and the decomposition of organic wastes to humus (Russell and Richards, 1917 ; Waksman *et al.*, 1929 ; Du Toit and Page, 1930, 1932 ; Waksman and Iyer, 1932, 1933 ; and others). This was accompanied by zealous attempts of other workers to discover how to make larger quantities of humic manures and how to increase the speed of the decomposition (Carbery and Finlow, 1928 ; Rao and Subrahmanyan, 1932, 1935 ; Anstead, 1932 ; Gadgil and Hegdekatti, 1937). These workers aimed at ensuring a copious supply of cheap and properly made humic manure.

Richards and Hutchinson (1921) artificially converted straw to humus by the help of ammonium sulphate. This led to the development of the patented " Adco " process.

Fowler (1930) and Howard concentrated their efforts on the utilization of all available organic residues for making composts of the Chinese type. Fowler stressed that it is necessary to build up an intensively active biological starter of the proper type to ensure a good start and maintain the speed thus secured throughout the course of decomposition. His system of making " activated composts " is founded on this principle and is applicable equally to both farm residues and town wastes.

Howard aimed chiefly at making all types of residues into composts and thus increasing the supply of cheap humus. He saw in this a means to compensate for the existing shortage of cattle dung for manure-making in India where cattle dung is badly needed for fuel purposes in the absence of a satisfactory substitute. His work in this direction culminated in the development of Howard and Wad's Indore Process (1931, 1935).

This process aims at utilizing the harder residues by making them less refractory to the influence of the fermenting micro-organisms by the physical cracking of tissues or by exposing them to the corrosive environment of

actively decaying material of a better composition. It lays special stress on starting the heap with a physical structure capable of maintaining adequate aeration without undue loss of moisture all through the period of decay notwithstanding its compaction due to the shrinkage of the rotting mass. It is maintained that a properly made heap will very soon develop within it all the required intensity of microbiological activity by itself. All the temperature ranges and sequences of the types of micro-organisms necessary for composting will automatically appear. The process is aerobic, clean, and sanitary as well as cheap and simple. The final product always maintains the proper standard of quality.

The process, therefore, spread rapidly all over the world and is applicable to a large variety of cultural systems and environments. It can convert all types of wastes quickly into well-rotted composts. This is typically illustrated by its application (1) to the disposal of habitation wastes (Jackson and Wad, 1934 ; Howard, 1935, 1937, 1938), (2) the composting of cane trash (Tambe and Wad, 1935 ; Dymond, 1923, 1938) and of sisal wastes, the wastes of tea, coffee, rubber and coconut and oil palms (Bagot, 1936 ; Howard, 1938) and its modifications for making composts with rain water (Timson, 1939) and by the intermittent supply of water from canals (Jackson, Wad, and Panse, 1934).

Fowler (1930) seems to have considered partially anaerobic conditions during the later stages of decomposing heaps as having some beneficial effect.

The author of this note has observed that under the hot arid climate of the Rajputana desert the compost made with three turns had an inferior chemical composition than that produced by one turn only. It appeared that due to the different degrees in the ease of fermentation of the various components of the heap the more easily decaying portions under the stimulus of local climate reached the stage of complete oxidation and consequent losses by the time the more refractory parts were sufficiently crumbled down. It is possible that losses of this nature may be kept down by lessening the number of turns or altering their intervals to regulate the ventilation to the desired degree.

While investigating the possibilities of the hot fermentation process Rajgopal *et al.* (1936) have concluded that in compost heaps a better conservation of carbon and nitrogen is possible when anaerobic conditions follow after a vigorous aerobic start with rise of temperature. The mechanism by which this is brought about is yet to be fully investigated.

Howard (1937) has recently evolved what he calls " Sheet Composting ". This seems to suit wherever labour is scarce or costly. Residues of field crops are composted *in situ* in the field without collecting and removing them. The conditions in sheet composting are perhaps semi-aerobic. The following description by Howard will illustrate an application of this principle :—

> This development was worked out during the last two years on the potato areas of South Lincolnshire which have been to suffer from shortage of humus. After the pea-crop grown for canning has been harvested, the land is immediately drilled with beans. The sown area is then covered

with a layer of crushed straw from the shelling machines followed by a thin layer of farmyard manure. The Indore process then sets in on the surface of the soil. The beans grow through the fermenting mass and at the end of September are ploughed in with the layer of finished compost. Decay is rapid and by the time the fields are planted in potatoes the following spring the resulting humus has been incorporated in the soil and is ready for nitrification. This modification is known as sheet composting—the making of humus in a thin layer all over the surface. Catch crops of beans or mustard or a crop of weeds can also be manured with humus or farmyard manure before ploughing-in in the autumn when sheet composting again takes place. The turf of old pastures or old leys can be converted into humus in a similar fashion. The Indore process has in this way been applied with success to no less than three important practical problems, green manuring, the effective utilization of weeds and stubble and the better utilization of the old turf of grass land.

Similar attempts at simplification are being made by applying waste organic matter direct to the soil with inorganic reinforcements (Eden, 1935, 1936). The present system of burying tea prunings and loppings of shade trees along with the chemical manures may also be considered a similar operation.

It appears to the author that perhaps the most economic and convenient method of returning waste material to land will be a preliminary aerobic decomposition to a suitable stage followed by direct application to the field, a few weeks before sowing time, before preparatory cultivation begins. There seems to be some scope for such a method as it involves the least deviation from current routine as well as the minimum of labour and care.

ANIMAL BREEDING METHODS USED IN THE FORMATION OF TYPES OF CATTLE SUITABLE FOR RAISING IN THE TROPICS*

A few years ago, the accepted method of animal production in the Philippines was to import already well established breeds from temperate countries to be acclimated here. Despite opposition, however, the work on formation of new breeds gradually gained momentum not only in the Philippines but in other parts of the tropical world. And to-day we find a number of newly-created types and breeds of cattle in different countries, notable among which are : the Santa Gertrudis in the state of Texas, U. S. A., Africander in the Union of South Africa, and Red Scindi and Sahiwal in India. A brief summary of the methods of breeding which have led to the formation of these new breeds of cattle is here reported.

THE SANTA GERTRUDIS BREED.

This breed of cattle was evolved at the King Ranch located in Texas, where Shorthorn and Hereford breeds of cattle had been kept in a pure state for at least thirty-five years (Kelley, 1932). In spite of close attention given to the breeding of these animals, it was found impossible to retain their size. Frequent introductions of fresh bulls from the best herds in the northern part of the United States and England proved ineffective in preventing degeneration of the stock. Not only did the size and type degenerate but the percentage of calving dropped steadily, frequently getting as low as 30 per cent. This fact notwithstanding, the method of pure breeding was adhered to in the hope that among the fifty thousand pure-bred Shorthorn and Hereford cattle on the King Ranch, some might finally become acclimated, since the climate in Texas, average annual temperature 19·9°C and humidity 68 per cent., was mildly subtropical. Crossbreeding was not resorted to until a crossbred Brahman bull, with Nellore blood predominating, came to the King Ranch as a gift. This bull was turned loose in a herd of pure Shorthorn cows. It was found later that the offspring of this bull by Shorthorn cows were very attractive. Hence, it was decided to try crossing Indian cattle (Brahman) with selected Shorthorn on a larger scale. A very oustanding bull named " Monkey " was produced in this crossbreeding work. The present breed of Santa Gertrudis cattle at the King Ranch may be traced back to the bull,

* By Miguel Manresa, of the Department of Animal Husbandry, of the College of Agriculture, University of the Philippines, in *The Philippine Agriculturist*, Vol. XXVIII., No. 6, November, 1939.

"Monkey" (Kelley, 1932; and Rhoad, 1938). A schematic diagram of the method used to develop the Santa Gertrudis breed is given below :

Method of breeding used in the formation of the Santa Gertrudis breed of cattle

Brahman-Durham-Shorthorn × Brahman-Shorthorn
$\frac{1}{2}$ 7/16 1/16 | $\frac{1}{2}$ $\frac{1}{2}$
("Monkey")

Brahman-Shorthorn × Brahman-Durham-Shorthorn
$\frac{1}{2}$ $\frac{1}{2}$ | $\frac{1}{2}$ 7/32 9/32

Brahman-Shorthorn × Brahman-Shorthorn-Durham
$\frac{1}{2}$ $\frac{1}{2}$ | $\frac{1}{2}$ 25/64 7/64

Brahman-Shorthorn-Durham*

THE PHILAMIN BEEF-DRAFT OX

The inability of well established breeds of cattle from temperate countries to live and reproduce normally in the Philippines led B. M. Gonzalez to devise a plan of crossbreeding with the object of determining the proportion of the different kinds of blood needed to produce an animal suitable for raising in the Philippines. The objective sought was a blend of the desirable characteristics of the western breed with cattle which can live in this country (Tuason, 1926). In Texas, the Hereford degnerated in size, but in the Philippines they generally died (Villegas, 1933). The higher annual temperature of the Philippines (26·9° C and over) than that of Texas may account for this difference. In the native home of the Hereford the average annual mean of temperature is 9·3° C ; humidity is 84 per cent.

In the work on crossbreeding cattle in the College of Agriculture, Hereford, males originating from Texas were mated with first-generation hybrid females from crosses between Indian Nellore and Philippine native. The products from these crosses were bred with first generation hybrids from Indian Nellores × Herefords. After a reasonable number of hybrid progenies had been produced from these and other matings, it was found that the animals possessing one-half Hereford, one-fourth Nellore, and one-fourth Native were superior to all other combinations when judged on the basis of size, reproductive capacity, and duration of productive life. Accordingly, all cows possessing this blood composition were gathered together and the best five were placed in a separate herd headed by the best bull from matings between pure Hereford males and Indian Nellore females. The bull selected to head this herd was "Provincial Fair", No. 93. These six animals constituted the foundation stock for the new breed of beef-draft oxen undergoing development in the College of Agriculture. The name Philamin was coined from the words

* Rigid selection was started beginning with the offspring of this generation. The work resulted in the formation of the Santa Gertrudis breed which has now been found suitable for raising not only at King Ranch, but in southern states of the United States where temperate breeds are not very profitable.

Philippines, American, and Indian (Manresa, 1934). A schematic diagram of the process involved in the formation of this breed follows :

Method of breeding used in the formation of the Philamin breed of beef-draft oxen

Philippine Native —— × —— Indian Nellore

Native-Nellore —— × —— Pure Hereford —— × —— Indian Nellore
½ ½

Native-Nellore-Hereford —— × —— Hereford-Nellore
¼ ¼ ½ ½ ½

Hereford-Nellore-Native *
½ ⅜ ⅛

ZEBU (BRAHMAN) CROSS CATTLE IN NORTH AUSTRALIA

The pastoral industry of the Northern Territory of Australia is said to have been initiated about fifty years ago. The nuclei herds were formed with cattle brought over from southern Australia, especially from Queensland. These and all other cattle which came into the territory later were British breeds. Slowly but steadily the cattle herds increased, and in 1932 there were about 700,000 cattle there (Kelley, 1932). If, however, the amount of labor and capital invested in the development of the cattle industry in the Territory which comprises over one-half million square miles is considered, the result can only be characterized as " woefully disappointing ". In that time other portions of the continent of Australia had achieved results unparalleled in the northern portions bordering the tropics. Hence, it was concluded that natural conditions must have militated against this enterprise in the North. The climate in North Australia is tropical, the annual mean of temperature being 26·5 C ; while that of the South is temperate.

As a matter of necessity the formation of breeds suitable for raising in North Australia was started. Brahman (Zebu) and Santa Gertrudis breeds were imported and crossed with British breeds. In one ranch, " Glen Prairie ", the attempt has been to establish a group of hybrids having slightly less than one-half but more than one-quarter Zebu blood, since it has been found that animals of this blood composition are suitable for raising under the tropical environment prevailing in North Australia. A schematic outline of the process involved is shown below :

Method of breeding used at " Glen Prairie " (North Australia)

Zebu-Santa Gertrudis —— × —— Santa-Gertrudis
½

Zebu × ¾ Santa Gertrudis ¼ Zebu

Zebu-Santa Gertrudis —— × —— Pure Hereford
⅝ ⅜

Zebu-S. Gertrudis —— × —— S. Gertrudis-Zebu-Hereford —— × —— Hereford ½ S. Gertrudis 3/16 5/16
⅝ ⅜ 3/16 5/16 ½

Hereford ¼
Santa Gertrudis 9/32
Zebu 15/32

Hereford ½
Santa Gertrudis 3/16
Zebu 5/16

* Beginning with this generation individuals of this blood composition were mated *inter se*, and thereafter the blood composition of the progeny resulting was disregarded. Selection and culling were practised rigidly in order to fix the type for the breed.

By continuing and extending the series of matings shown above, two groups of hybrids arise: one possessing about one-half Hereford blood, the other 15/32 Zebu blood or nearly one-half (Kelley, 1938). The essential feature of the foregoing method is that it combines the methods used in the formation of the Philamin and Santa Gertrudis breeds of cattle. The former method attempted to maintain the Hereford blood in the proportion of about 50 per cent., whereas the latter has maintained the same average proportion of blood, namely one-half, in the Zebu.

THE RED SCINDI CATTLE

From a number of the newly created breeds of cattle intended for dairying, the best known in the Philippines at present is the Red Scindi (San Agustin, 1934; Villegas, 1935a). This breed was developed in the district of Karachi, province of Scindh, India, from a purely indigenous stock of cattle without the introduction of foreign blood. It is reported that the ancestors of this breed were small-sized animals (Matson, 1918). By methodically practising continual selection and culling, a fairly large animal yielding a reasonably large quantity of milk was evolved.

The average yield of three imported Red Scindi cows in the College of Agriculture from 1933 to 1938, inclusive, is well above five liters a day during a lactation period of not less than 300 days. Bulls of this breed in their original home weigh from 430 to 450 kilograms, cows from 300 to 350 kilograms. Exceptionally large bulls may weigh 660 kilograms at maturity. According to Littlewood (1936), "it is one of the purest and most distinct of the Indian breeds of cattle; it is moreover the only breed of commercially profitable dairy cattle in this country (India) outside of the buffaloes which can be purchased in large numbers."

THE SAHIWAL BREED

During the trip through India made by the writer in the summer of 1937, he found that the Sahiwal breed of dairy cattle, formerly known as Montgomery, came next to the Red Scindi breed in point of number but not in individual performance as a milk producer. This breed traces its origin from one of the Punjab states, and the credit for the unification of type and increased production belongs to the Imperial Agricultural Research Institute which started to function in Pusa from where it was transferred to New Delhi, India. In 1913–1914 a herd of selected Sahiwal cows consisting of 49 head gave an average of only 2·6 liters of milk daily (5·8 lb.) during a lactation period of 44 weeks or 307 days. Under proper breeding methods and management the average milk yield of the herd improved steadily from 2·6 liters per cow per day in 1914 to 3·0 liters in 1918, 4·3 liters in 1923, and 5·7 liters in 1928.*

Special handling of the heifers and cows, beginning in 1932, accelerated the improvement of milk yield. Under such a method the average daily production per cow in the herd was raised from 6·17 liters in 1932 to 8·30 liters in 1934,

* General observations on animal husbandry in India.—*The Philippine Agriculturist*, 26: 341–376.

and from 8·30 liters in 1934 to 9·56 liters in 1936 (Manresa, 1937). This method of special handling, among others, included (1) early training, (2) milking four times a day instead of two or three times, and (3) pre-milking, *i.e.*, milking heifers and cows before they have dropped their calves (Sayer, 1937).

At the time of the writer's visit to the dairy farm of the Imperial Agricultural Research Institute located at New Delhi, India, the cow rated as lowest producer in the herd of the Sahiwal cattle yielded 2,260 liters in her previous lactation. The best cow in the herd was surpassing her previous lactation record of 4,536 liters. The average milk yield for the herd was 2,948 liters per cow lactation of 44 weeks duration, or 307 days (Manresa, 1937). One of the objects of the work of the Imperial Agricultural Research Institute in connection with this breed was to develop early maturity.

THE BATANGAS TYPE OF PHILIPPINE NATIVE OXEN

In this College, work on the improvement of Philippine Native cattle has been going on since 1919. In this work the method of selection and culling without introduction of exogenous blood is being used. The foundation animals were largely of the Batangas type since in that province the best stock of native oxen in the Philippines are found. The progenitors of these cattle are said to be of Mexican and Chinese origin introduced into the Philippines during the early years of the Spanish regime (Villegas, 1935b). In spite of inattention to breeding, care, and management, the cattle population in the Philippines increased steadily. In 1936 the number of cattle in the Philippines was well above one and one-half millions. Natural selection rendered these animals rather small in size. Bulls averaged 350 kilograms in weight at maturity. It was not so easy, therefore, to secure the bull of suitable weight, type, and conformation to head the foundation herd of native cattle. Search for this bull covered a period of several years over wide territory in the provinces of Batangas, Laguna, Rizal, and Tayabas. The first step in this work has been to improve the size of the animals, and progress in this direction is being attained much faster than expected.

IMPROVEMENT ON THE INDIAN NELLORE BREED

The stock of Indian Nellore breed of cattle undergoing improvement in the College of Agriculture descended from those imported in large numbers by the Philippine Government from India in 1918. This importation consisted of 546 animals of which 224 were males (Alano, 1935). Two bulls and six cows were purchased by the College but steps towards the improvement of the stock were not taken until about six years later when the animals were first used in crossbreeding experiments involving Philippine and European cattle. After the nuclei herds for various projects had been formed, all the pure-bred Nellore still remaining were put together and a definite program for purposes of improvement was followed. This work has been going on for eleven years and the results indicate the existence of great possibilities for success in every productive direction. One of the bulls produced in the herd weighed 463

kilograms at the age of three and one-half years and 644 kilograms at maturity. The cropping out of many heifers with well-developed udders is a great temptation for anyone who wishes to develop a dual-purpose breed of Nellore cattle suitable for the average Filipino farmer. In this herd of Nellores many heifers and cows owing to excess milk, have had to be milked after calving to save their udders from caking and their calves from scouring.

In India the Nellore cattle, called Ongole in that country, are not outstanding for milk production. Some fairly high yielders of milk, however, have been reported from time to time over wide territories. This justified the establishment of the Ongole Cattle Farm in 1918 in the district of Nellore, Madras Presidency (Littlewood, 1936). As a nucleus herd for the Ongole Cattle Farm forty-six selected cows and five bulls were put together and placed under close observation. After weeding out the irregular and late breeders twenty-five cows were retained. The heifers born to these cows were mated to good bulls. In 1931 the selected cows averaged 4·5 liters of milk daily during a rather short lactation period. By eliminating from the herd cows which produce milk for shorter periods, the average yield was improved, and five years later (1936) the daily production of the herd was increased by about 1·4 liters.

SUMMARY AND CONCLUSIONS

In the production and improvement of cattle suitable for tropical countries like the Philippines, two methods of breeding have been found to yield satisfactory results: (1) the improvement of the stocks of cattle which have become adapted to the environment prevailing in definite localities in each country, and (2) the formation or creation of new breeds by blending the desirable characteristics of the western breeds with those which can live in the tropics. The practicability of these methods has been demonstrated in all parts of the tropical world. The former method, although slower, has the advantage of availability to the greatest number of live stock raisers, as it requires but little extra capital. The latter method is ordinarily more expensive because of the necessity of keeping many herds and a large number of animals in the herds as material for selection. Hence this work has generally been left to institutions supported entirely or at least in part by governments.

In the adoption of either the first or the second method of breeding, it is important to keep in mind that little can be accomplished unless there is a well-defined policy governing the work and, above all, a permanent one. Failure in the past to achieve lasting results in animal improvement has been due to recurrent shifting of methods and objectives according to individual preferences and changing personnel Hence, results accomplished through years of painstaking effort were quickly lost or nullified through whims or personal ambitions of new men who were not bound by well-defined goals and were always ready to launch a novel program for the sake of appearing original and efficient.

MEETINGS, CONFERENCES, &c.

RUBBER RESEARCH SCHEME (CEYLON)

DRAFT MINUTES OF THE FORTY-NINTH MEETING OF THE RUBBER RESEARCH BOARD HELD IN THE CHAMBER OF COMMERCE BUILDING, COLOMBO, AT 10 a.m. ON THURSDAY, OCTOBER 12TH, 1939.

Present.—Mr. E. Rodrigo, C.C.S. (in the Chair); Mr. T. Amarasuriya; Mr. C. H. Collins, C.C.S. (Deputy Financial Secretary); Mr. I. L. Cameron; Mr. W. P. H. Dias, J.P.; Mr. L. B. de Mel, J.P., U.P.M.; Mr. G. E. de Silva, M.S.C.; Mr. T. C. A. de Soysa; Mr. A. W. Harrison; Mr. J. C. Kelly; Mr. F. A. Obeyesekere; Mr. L. E. Russell; Mr. B. M. Selwyn; and Mr. N. D. S. Silva, O.B.E., J.P.

Mr. T. E. H. O'Brien, Director, was present by invitation.

1. MINUTES.

Minutes of the meeting held on June 21, and of the adjourned meeting held on July 3, 1939, were confirmed and signed by the Chairman subject to minor corrections in the record of the statement made by Mr. H. J. Page at the adjourned meeting.

2. STABILIZATION OF INCOME FROM CESS COLLECTIONS.

Reported that a memorandum embodying proposals for stabilization of the Board's income from cess collections had been forwarded to the Ceylon Estates Proprietary Association, Low-country Products Association, Planters' Association of Ceylon, and the Rubber Growers' Association for consideration, after approval by the Board by circulation of papers. So far replies had been received from two Associations and it was decided to await the other replies before considering the matter further.

3. SMALLHOLDINGS COMMITTEE.

Recommendations made at a meeting held on September 23, 1939, were considered.

(*a*) *Demonstration Nurseries.*—Decided that budded plants from demonstration nurseries should be sold to smallholders on the same terms as plants budded in the nurseries at Nivitigalakele.

(*b*) *Pamphlet on dirt in Rubber.*—Decided that a pamphlet suggesting methods for preventing the contamination of rubber with foreign matter should be distributed to all smallholders and that the co-operation of the Rubber Controller should be sought in distributing the pamphlets.

4. EXPERIMENTAL COMMITTEE.

Recommendations made at meetings held on July 31, and September 21, 1939, were considered.

(*a*) *Visiting Agent's Report.*—The Visiting Agent's report on his inspection of Dartonfield and Nivitigalakele estates on May 16, 1939, was adopted.

(*b*) *Planting Food Crops.*—The recommendation that an area of 3 acres at Nivitigalakele should be cleared for use as a Rubber seedling nursery and temporarily utilized for planting food crops was adopted.

(*c*) *Bungalow for Geneticist.*—Agreed that the construction of a bungalow for the Geneticist be postponed in view of the unsettled international situation.

(*d*) *Oidium Leaf Disease.*—It was noted with satisfaction that arrangements had been made for a search for Oidium resistant trees to be conducted on a number of estates in the Matale District during the next refoliation season.

(*e*) *Replanting Experiment in 1941.*—The recommendation to lay down a 5–acre replanting experiment at Dartonfield in 1941 to test certain new clones on a variety of clonal stocks, was approved and it was agreed that heavy tapping on experimental lines should be undertaken in the area in 1940.

(*f*) *Tapping Experiment at Mukalana Estate.*—Approval was given to proposals for a tapping experiment to be undertaken on Mukalana Estate to study the mutual influence of stock and scion, a suitable block of trees budded at a height of 3 ft. being available. The terms of a tapping lease of the area were endorsed and the action of the proprietors of the estate in providing facilities for the experiment was noted with appreciation.

5. ACCOUNTS.

(*a*) Statement of receipts and payments of the Board for the quarter ended June 30, 1939, was adopted.

(*b*) *Dartonfield and Nivitigalakele accounts* for March, April, May, June, and July, 1939, were tabled.

(*c*) *Estimates of Income and Expenditure for 1940.*—Estimates of income and expenditure for 1940 were considered and adopted subject to minor alterations. The following is a summary of the estimates as adopted.

		Rs.	Rs.
Income	.. .. ..		212,975
Expenditure :	Revenue Account	199,157	
	Capital Account ..	6,722	
			205,879
Surplus of income over expenditure			7,096

6. STAFF.

(*a*) *Mr. R. K. S. Murray.*—Reported that Mr. R. K. S. Murray, Botanist and Mycologist, had returned from leave on October 9.

(*b*) *Mr. C. A. de Silva.*—Reported that Mr. C. A. de Silva, Assistant Botanist, had accepted re-engagement for a period of 4 years from September 9.

(*c*) *Officers on Military Service.*—Reported that Mr. M. W. Philpott, Chemist, and Dr. C. E. Ford, Geneticist, had been mobilized with the Ceylon Defence Force during September. It was agreed that the rules regarding the payment of salaries to Government officers serving with mobilized units of the Defence Force should also apply to Research Scheme officers.

7. *Technical Officers' Progress Reports for the Quarter ended June 30, 1939*—were adopted

8. *Co-operation with British Rubber Producers' Research Association*—A letter was read from the Director of the British Rubber Producers' Research Association offering the close co-operation of his Association. The policy of reciprocal co-operation was cordially approved.

9. *Issue of Publications to Holders of Permits for New Planting.*—Arising from the application of a holder of a permit for new planting to be registered for free issue of Research Scheme publications it was agreed that publications should be supplied without charge to applicants who were planting areas exceeding 10 acres.

The meeting terminated with a vote of thanks to the Chamber of Commerce for the use of the Committee Room.

Research Laboratories,
Dartonfield,
Agalawatta,

November 14, 1939.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD IN THE ROOMS OF THE CEYLON CHAMBER OF COMMERCE, COLOMBO, ON FRIDAY, OCTOBER 13, 1939, AT 2.30 P.M.

Present.—Mr. James Forbes (Chairman); The Hon. The Financial Secretary (Mr. H. J. Huxham); The Director of Agriculture (Mr. E. Rodrigo); The Chairman, C.E.P.A. (Mr. C. H. Bois); Major J. W. Oldfield, C.M.G., O.B.E., M.C., M.S.C.; Messrs. I. L. Cameron; J. D. Hoare; J. C. Kelly; T. B. Panabokke; S. F. H. Perera; Gordon Pyper; and Dr. R. V. Norris (Director and Secretary).

A letter was received from Mr. R. C. Scott expressing inability to attend the meeting.

1. The Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board held on July 13, 1939, were confirmed.

3. **MEMBERSHIP OF THE BOARD AND SUB-COMMITTEES.**

Board.—Reported that Mr. R. C. Scott, had resumed his seat on the Board on his return from leave, *vice* Mr. C. M. W. Davies.

The Chairman thanked Mr. Davies for his services while acting.

Estate and Experimental Sub-Committee.—The Board nominated Mr. Gordon K. Newton as a Member of the Estate and Experimental Sub-Committee, *vice* Mr. C. Huntley Wilkinson, vacated.

4. **FINANCE.**

(*a*) The Institute's Accounts to August 31, 1939, were approved on the motion of Mr. J. C. Kelly, seconded by Mr. I. L. Cameron.

(*b*) The Chairman reported that the Interest and Capital payments due on the Government Loan were duly met on September 27.

(*c*) A revised Forecast of Receipts and Expenditure for 1939 was tabled. The Chairman said that reduced profits on estate account due to low crop figures would, it was expected, be balanced by savings in other directions. The final position at the end of the year would be very much the same as that given in the original forecast presented with the estimates.

The Board accepted the statement.

(*d*) *General Financial Policy for 1940.*—A statement prepared by the Director was tabled.

(i.) The Chairman said the matter had been considered by the Finance Committee which recommended that the rate of restriction as from April 1, 1940, should be taken as 92½ per cent. This was approved.

(ii.) The Committee had also approved the Director's proposals that, while avoiding any expenditure both under revenue and capital accounts not immediately essential, the normal programme of work should so far as possible be maintained.

The Board approved of this policy.

(iii.) The Committee had also considered the question of the appointment of an additional research officer for work on phloem necrosis. In response to the Institute's advertisement seven applications had been received in London. This was somewhat unexpected in view of the outbreak of the war. The Ceylon Association had now cabled to inquire if the Board wished to proceed with the scheme.

The view of the Finance Committee was that the technical points of the scheme remained unchanged and they had therefore considered the appointment mainly from the financial aspect, particularly in regard to the desirability or otherwise of increasing the Institute's commitments during the war.

In the opinion of the Committee, the appointment could be financed and they unanimously recommended to the Board that the appointment be made.

The Chairman reminded members that the candidates would be interviewed by a Selection Committee consisting of Sir Frank Stockdale, Sir John Russell, and Professor Engledow. They could rest assured, therefore, that no one but an entirely suitable man would be recommended.

Mr. Cameron strongly supported the recommendation of the Finance Committee.

After further discussion the Board uanimously decided to proceed with the appointment of a research officer for work on phloem necrosis.

(*e*) The Board approved an extra vote of Rs. 60 under vote 73, Research Revenue Account, being the cost of a caretaker for the Plant Physiologist's bungalow for the term October-December, 1939.

5. ST. COOMBS ESTATE.

(*a*) *Sale of St. Coombs Tea Crop.—The Chairman* reported that a tender of 30,000 lb. tea had been made to the Tea Commissioner and had been accepted by him. The balance of the crop would be sold in the usual way on the Colombo Market.

In reply to *Mr. Pyper*, the Chairman said owing to the outbreak of war, the Clivemeare experiment, so far as commercial manufacture was concerned, had been suspended. One Clivemeare invoice, No. 14, had been shipped, but no useful market information would now be obtained. A second Clivemeare invoice had been sold locally. B.O.P. had sold for Re. 1·07 and F.P. for Re. 1·15 but these prices had little significance under present market conditions.

(*b*) *Extra Votes.*—The Board sanctioned the following additional votes on estate account :—

(i.) Rs. 480 being cost of installing extra liquid fuel tanks.

(ii.) Rs. 587 to meet increased cost of manure required to complete the cultivation programme for 1939.

(*c*) *Food Production.*—The Chairman said the question of food production on St. Coombs had been under discussion between himself and the Director.

The Institute was rather different from an ordinary estate and he thought a lead should be given in the matter.

It was suggested that 1 acre should be put down under roots and nursery trials carried out with other crops to ascertain what varieties would be suitable for the conditions at St. Coombs.

If such trials were successful he suggested that an area of 10 acres might later be opened up for food production.

The Director said that in any food production scheme adequate steps should be taken to avoid soil erosion. A rotation would also be essential. It was also probable that satisfactory crops would not be obtained without manuring.

It would not be feasible to do anything on a large scale before the Spring but, in the meantime, the nursery experiments suggested should give valuable information in regard to the right type of crop to grow and the time required for different varieties to mature. In this way mistakes and waste could be avoided if a larger block were opened later. The Institute was in close touch with the Agricultural Department and had been promised every assistance in regard to seed supplies and advice.

After further discussion the Board approved the proposal to open 1 acre under roots and to conduct nursery trials with a view to larger scale work in 1940 A sum of Rs. 100 was sanctioned for this preliminary work.

6. **JUNIOR SCIENTIFIC STAFF.**

The appointment of Mr. F. D. Tillekeratne as Smallholdings Advisory Officer, Baddegama, was confirmed as from Augsut 31, 1939.

7. **RESEARCH ON THE CHEMISTRY OF TEA.**

The Board confirmed the payment to the Ceylon Association in London of £187. 10*s*. 0*d*.being cost of the Joint Scheme for the first six months of 1940. This had been already approved by circulation of papers (Circular No. B1/39 dated August 3, 1939).

The Chairman said no information was yet available as to the effect the war would have on the scheme.

8. **ANY OTHER BUSINESS**

(*a*) *Visit to Assam.*—Reported that the visit of the Chairman and Director to Assam had been abandoned on account of the war.

(*b*) *Conference Committee.*—Reported that the Planters' Association of Ceylon, and the Ceylon Estates Proprietary Association had both approved the Board's proposal, *vide* Minutes of July 13.

ROLAND V. NORRIS,
Secretary.

Tea Research Institute of Ceylon,
St. Coombs,
Talawakele,

October 30, 1939.

CORRESPONDENCE.

THE TRANSPORT OF HATCHING EGGS FROM ENGLAND TO ZANZIBAR

Ref. No. D. 33/2203,

The Editor,

The Tropical Agriculturist,
Department of Agriculture,
Peradeniya,
Ceylon.

Department of Agriculture,
P.O. Box 159,
Zanzibar,
East Africa,
October 20, 1939.

SIR,

THE following account of a trial consignment of sixty eggs sent by Imperial Airways from England to Zanzibar may be interest to your readers :—

2. The eggs were received in Zanzibar on July 23, 1939, in five boxes divided into twelve compartments and lined with felt, the eggs being packed in these compartments with bran. The boxes were not nailed but tied with string. When the boxes were opened, it was found that two eggs were broken, another was accidentally broken when taking them out and the remaining 57 eggs were set under 7 hens on the morning of July 23, 1939. The hens sat very well and were let off the nests every morning for about 20 minutes. The eggs were not examined during the period of hatching. On August 2 an egg was broken by hen No. 2 and on the 11th one by hen No. 5. On August 13 hen No. 1 hatched three chicks, they being the only eggs to hatch out of the total set. All the eggs were then examined and broken open and it was found that all of them with one exception were addled, one contained a dead chick. The addled eggs were odourless.

I have the honour to be,
Sir,
Your obedient servant,
R. W. R. MILLER,
Director of Agriculture.

Possible causes of the poor results obtained in this case are :

(*a*) the unfavourable season of the year. July in England is a month when most of the breeding pens will have been broken up to rest the birds, moulting will be starting and the vitality of the birds will be at a low ebb. Eggs from such birds will not give good hatching results.

(*b*) the fact that the eggs were found broken on arrival, in spite of good packing, indicates that the boxes received rough handling on the journey. Ed. T.A.]

ANIMAL DISEASE RETURN FOR THE MONTH ENDED NOVEMBER 30, 1939

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1939	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Rinderpest	7	..	..	..	..	7
	Anthrax	12	..	10	2	..	..
	Rabies	2	..	..	..	..	2
	Piroplasmosis	8	2	1	7	..	..
	Haemorrhagic Septicaemia	3	..	3	..	..	..
	Blackquarter	1	..	1	..	..	..
Colombo Municipality	Foot-and-mouth disease	33	..	3	29	..	1
	Anthrax	1	..	1	..	..	..
	Rabies	5	2	5	..	..	.
	Piroplasmosis	6	..	1	5	..	.
Cattle Quarantine Station	Foot-and-mouth disease	2	..	..	2	..	..
	Anthrax	29	..	29	..	..	
Central	Bovine Tuberculosis	1	1	..	..	..	1
	Foot-and-mouth disease	562	..	3	559	..	..
	Anthrax	5	..	5	..	..	..
	Rabies	11	2	4	..	..	7
	Contagious mange	18	..	2	16	..	..
	Blackquarter	9	..	8	..	..	1
	Piroplasmosis	10	..	2	8	..	..
Southern	Foot-and-mouth disease	665	..	31	634	..	..
	Rabies	16	5	..	..	..	16
	Haemorrhagic Septicaemia	6	..	6	..	..	..
Northern	Foot-and-mouth disease	130	..	7	123	..	..
	Blackquarter	105	45	102	3	..	..
	Rabies	1	..	..	..	..	1
Eastern	Foot-and-mouth disease	5	..	..	5	..	..
	Anthrax	48	..	48	..	..	..
North-Western	Foot-and-mouth disease	122	..	3	119	..	..
	Haemorrhagic Septicaemia	23	..	23	..	..	..
	Rabies	14	2	2	..	..	12
	Contagious mange	18	..	..	18	..	..
	Piroplasmosis	1	..	..	1	..	..
North-Central	Foot-and-mouth disease	1,695	..	10	1,685	..	..
	Blackquarter	31	..	31	..	..	..
Uva	Foot-and-mouth disease	269	46	25	202	42	..
Sabaragamuwa	Haemorrhagic Septicaemia	3	2	3	..	..	..
	Rabies	6	1	..	..	..	6

A. JAYASINGHA,
for Deputy Director (Animal Husbandry)
and Government Veterinary Surgeon.

Department of Agriculture,
Peradeniya, December 16, 1939.

METEOROLOGICAL REPORT, NOVEMBER, 1939

Station	Temperature				Humidity		Amount of Cloud	Rainfall		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Agalawatta ..	84·7	—1·9	71·3	—0·6	80	93	6·2	21·68	21	—
Anuradhapura ..	85·1	—0·3	71·9	+0·3	78	95	6·9	16·48	16	+ 4·94
Badulla ..	79·2	+0·1	66·1	+0·6	74	92	6·0	8·92	18	— 1·10
Batticaloa ..	84·3	+0·2	74·5	+0·2	78	90	5·4	14·22	14	— 1·66
Colombo ..	84·5	—0·4	73·9	+0·4	78	93	7·2	19·71	20	+ 7·37
Diyatalawa ..	73·8	—0·3	60·5	+0·4	84	94	7·4	11·23	21	+ 1·04
Galle ..	82·7	—0·7	74·8	+0·7	77	84	6·8	15·33	19	+ 4·19
Hakgala ..	67·6	—1·0	55·2	+0·9	89	94	7·8	15·14	19	+ 3·09
Hambantota ..	84·9	—0·4	74·6	+0·8	80	93	6·2	5·62	18	— 2·16
Jaffna ..	83·9	+0·4	75·0	+0·4	78	90	6·1	35·35	17	+19·03
Kandy ..	82·6	—0·9	68·9	+0·8	68	92	7·8	18·15	20	+ 6·94
Kurunegala ..	86·3	—0·7	72·7	+0·9	74	93	7·0	12·81	18	— 0·71
Lunuwila ..	84·8	—1·0	73·4	+1·1	82	95	6·9	12·03	21	—
Mannar ..	83·4	—1·3	75·8	+0·3	80	86	7·3	18·23	19	+ 8·38
Nuwara Eliya ..	66·3	—1·8	53·4	+2·1	85	94	8·7	12·38	20	+ 2·87
Puttalam ..	85·6	+0·4	73·6	+0·4	78	93	7·2	12·50	21	+ 2·54
Ratnapura ..	85·8	—1·8	72·7	+0·4	80	95	7·0	14·81	22	— 0·19
Talawakele ..	72·1	—1·1	58·7	+1·6	76	88	7·2	9·50	17	—
Trincomalee ..	83·8	+0·5	74·7	—0·1	76	88	6·0	14·59	17	+ 0·33

The rainfall for November was on the whole above normal, the largest excesses being found in the north of the Island and in the Hiniduma-Baddegama area in the south-west. Slight deficits, however, were recorded at an appreciable number of stations scattered throughout the Island, except in the north. The largest deficits were 6·56 inches at Keenakelle and 6·45 inches at Eheliyagoda. The largest excesses were 24·52 inches at Jaffna College, 23·38 inches at Chavakachcheri, 21·26 inches at Jaffna Farm School, while excesses of over 15 inches were also recorded at Jaffna meteorological station, Iranaimadu and Madhu Road.

The highest monthly totals were 41·69 inches at Chavakachcheri and 40·71 inches at Jaffna College, while totals of over 30 inches were also recorded at Jaffna Farm School, Ramanathan College and Jaffna meteorological station. The only station that had less than 5 inches for the month was Hambantota Saltern with 3·12 inches.

There were as many as 146 daily falls of 5 inches and over reported during the month, the majority of these occurring on the 14th or 15th. In 12 cases, falls of 10 inches or more were recorded. The oustanding amounts were 21·17 inches at Chavakachcheri, 15·00 inches at Jaffna College, 14·20 inches at Ramanathan College, and 13·63 inches at Jaffna meteorological station, all on the 15th.

About the 6th the weather conditions became somewhat unsettled and pointed to the possibility of a depression forming off the east or north-east coast. This, however, was not fulfilled, but a trough of low pressure persisted over the Island for a day or two.

The most interesting feature of the weather was the effect of a depression that formed in the Bay of Bengal later in the month. First signs were noticeable on the morning of the 14th. Conditions steadily deteriorated, and by the morning of the 15th a deep depression, possibly storm, was identified off the north-east coast of the Island. This travelled along the coast in a north-westerly direction and crossed the Indian coast near Negapatam on the morning of the 16th. Thereafter it gradually weakened. As a result of this depression, very heavy widespread rain occurred over the Island on the 14th and the 15th.

Temperatures were in general below normal by day and above normal by night. Humidity and cloud amounts were irregularly distributed on either side of average. Winds were above average strength and of variable direction.

D. T. E. DASSANAYAKE,
Acting Superintendent, Observatory.

Issue Date	Issue Date	Issue Date	Issue Date